POWER

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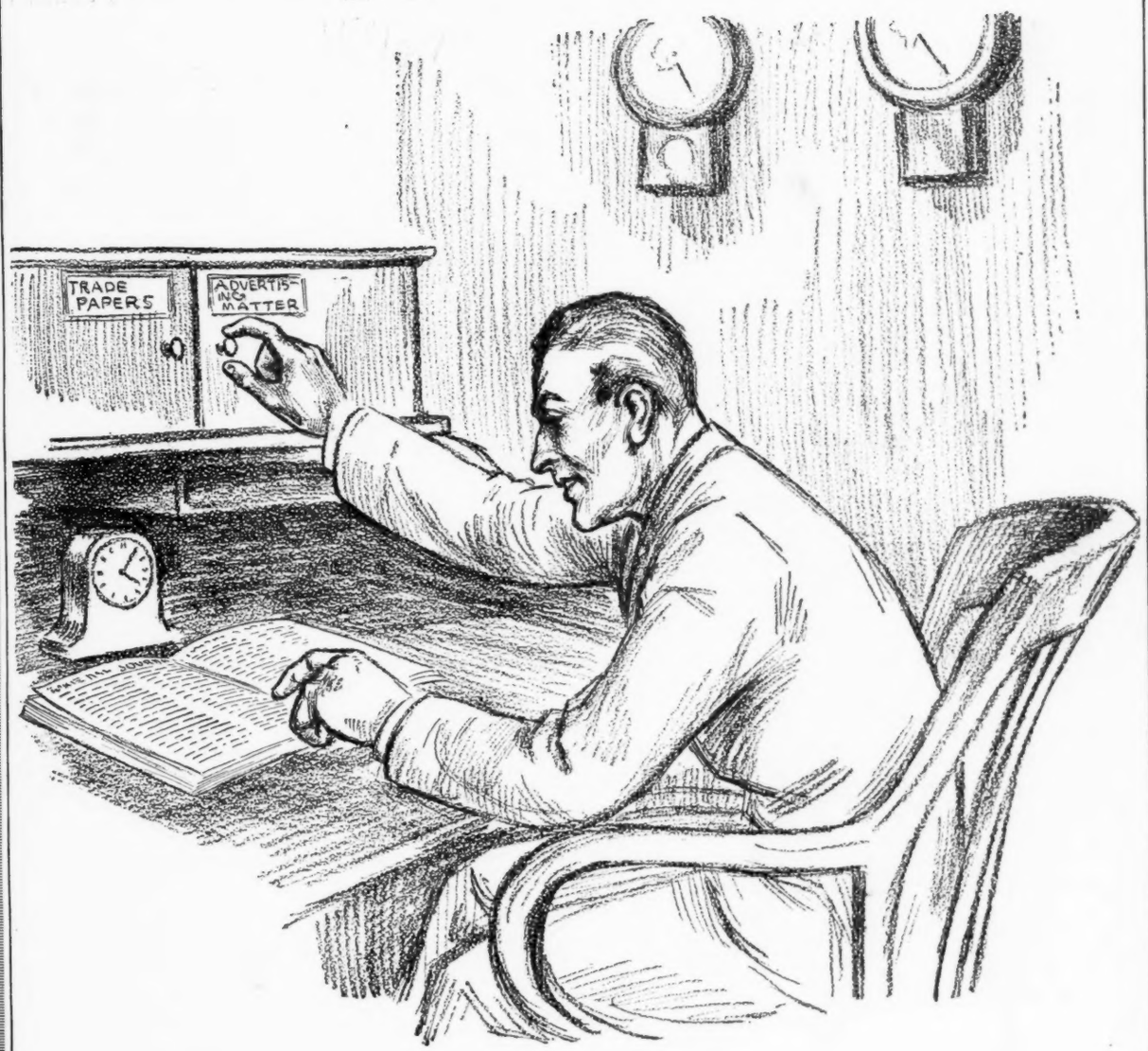
HELPFUL HINTS



The Uptodate Engineer Files His Technical Papers and Advertising Literature for Future Reference.

Suggested by PHILLIS, *Pittsburgh, Penn.*

Largest Boilers for Ford Co.

By John P. Badenhausen, M. M. E.

SYNOPSIS—Six-drum, single-ended boilers, each having 25,000 sq.ft. of heating surface and covering a floor area of 384 sq.ft. These are the largest boilers ever installed in this country. A feature is a preheating section at the rear.

At the new Highland Park plant of the Ford Motor Co. the boiler question meant more than simply the matter of installing boilers of reasonable capacity—it meant using the present boiler-room volume to the best advantage so that the horsepower obtained from such a given volume should be the highest possible with a practicable installation. For example, each bay has an available width of 27 ft., depth of 45 ft., and height of 35 ft., making an available volume of 42,525 cu. ft. The present boiler room was designed to hold 14 bays, each containing two 400-hp. boilers, or a total of 800 hp. per bay. With Taylor stokers and boilers operating at 150 per cent. of rating continuously, a combined efficiency of 72 per cent. could be maintained, and this would mean 800 hp. plus 50 per cent., or 1,200 hp., delivered per bay of 42,525 cu.ft. The ratio of volume to horsepower is then $\frac{42,525}{1,200} = 35.44$ nearly, or in other words, one horsepower needs 35.44 cu.ft. of boiler-room volume. This means at an average price of 50c. per cu.ft. that one horsepower delivered requires $17.72 of building. By using very large boilers, an efficiency of 80 per cent. could be expected at 160 per cent. of rating. Large stokers could be used and more coal could be burned under these large boilers, with the result that better use could be made of the space available. The large boilers installed are expected to deliver continuously 4,000 boiler horsepower per bay. Again, referring to the volume-horsepower ratio, $\frac{42,525}{4,000} = 10.6$ cu.ft. of building per horsepower, or at 50c. per cu.ft. $5.30 worth of building is required, a saving of $17.72 − $5.30 = $12.42 per horsepower. Multiplying the total horsepower to be installed in the 14 bays by the saving in building gives 56,000 × $12.42 = $695,520, a tremendous saving not only in money but also in space occupied.

By reason of the higher economy of the larger boilers further savings will be made. When operating twelve boilers continuously and delivering 4,000 hp. from each, or 50,000 hp. in all, the saving in coal is estimated at about 14 per cent., amounting to about $200,000 per year. Such results can be obtained only by carefully studying all conditions, and it is rather interesting to follow the methods by which the final details of design were arrived at.

The writer was instructed by W. B. Mayo, designing engineer of the Ford Motor Co., to suggest boilers to be installed in the space available without making any changes in the boiler room except those necessary in the foundation to accommodate the boilers and stokers.

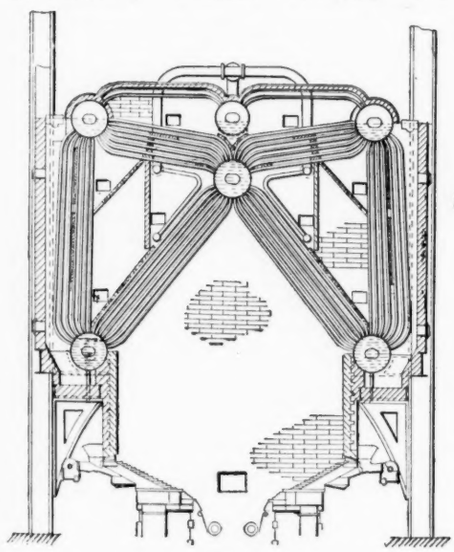


FIG.1

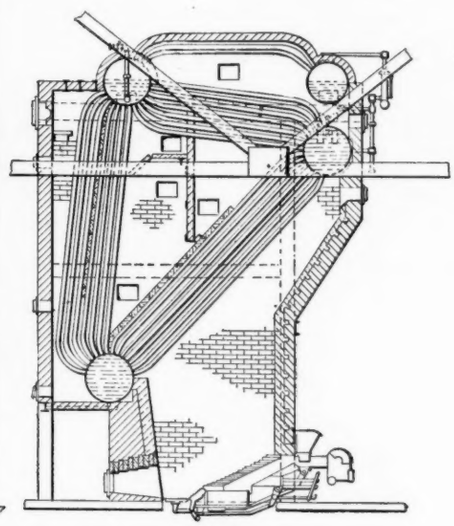


FIG.2

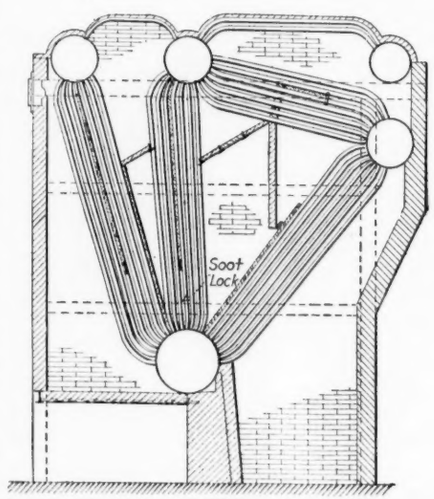


FIG.3

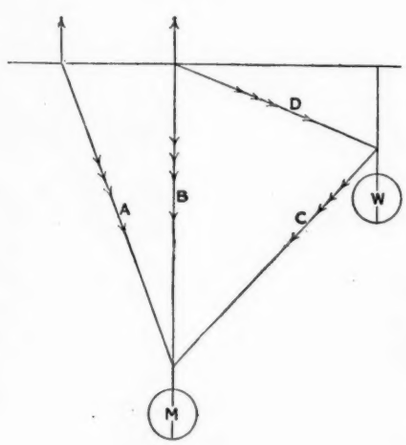


FIG.3-A

DESIGNS CONSIDERED FOR FORD PLANT

Fig. 1—Double-ended boiler first proposed. Fig. 2—Standard single-ended Badenhausen boiler. Fig. 3—Third design, which has a number of objections

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From the many studies and sketches made by the writer to solve the problem of installing the boilers and stokers so as to make the best use of the space and volume available, the whole matter boiled down to four designs, of which only the last was finally offered and accepted. The first study was to use a double-ended Badenhausen boiler of standard design (see Fig. 1) having 30,000 sq. ft. of heating surface and two firing fronts, the boiler to be served by Taylor stokers, standard size, 12 retorts per front. Units of this size are entirely practicable, as boilers of 45,000 sq.ft. each have been designed by the Badenhausen Co.

While making excellent use of the space, this design would necessitate expensive changes in the boiler room, such as the installation of additional bunkers, and owing to narrow aisles would not allow good operating conditions.

The second design (shown in Fig. 2) was a standard single-ended Badenhausen boiler having only 15,000 sq.ft. of heating surface. While a step in the right direction, it did not make the most of the volume available, but seemed to be the limit, and at one ti its use was practically decided upon.

Further careful consideration fro ery angle brought out the design shown in Fig. 3, w a, while giving more

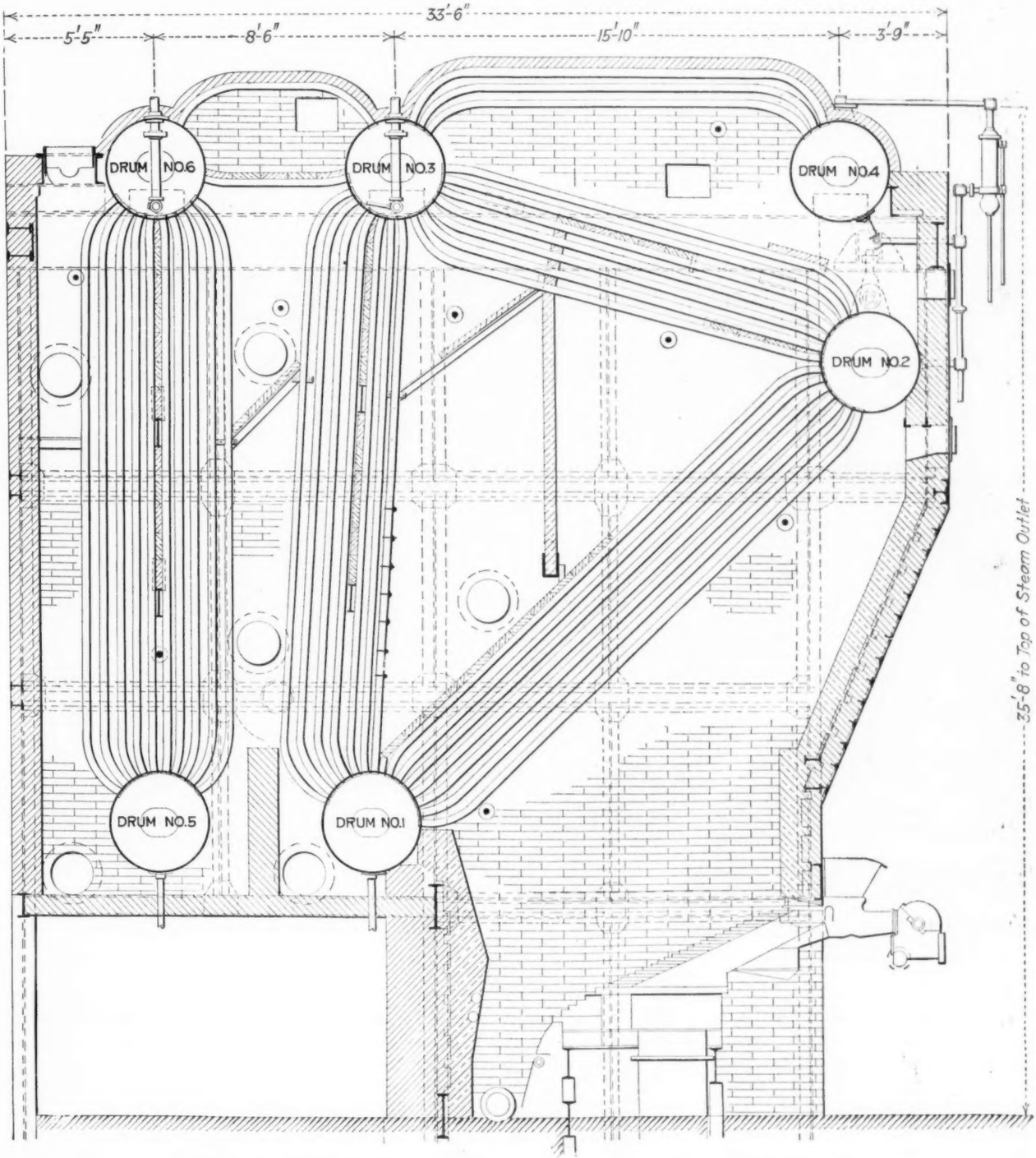


FIG. 4. FOURTH DESIGN, WHICH WAS FINALLY ACCEPTED AND INSTALLED

heating surface than design No. 2, the standard Badenhausen boiler, had some objectionable features, causing its rejection and the adoption of the design finally accepted and installed. The first objection to the design shown in Fig. 3 is that the mud drum is suspended from three supports, so that there will always be two banks of tubes in tension and one in compression.

In his excellent article on boiler tubes and expansion, published in *Power* of Jan. 25, 1916, John C. McCabe, chief boiler inspector of Detroit, went thoroughly into these matters. In such a large unit as the one under consideration, all faults due to differences of temperature in the water in the various parts of the boiler would be greatly accentuated and would produce stresses and strains that might cause the destruction of the tubes and drums. Here 4,000 hp. meant 120,000 lb. of water, comparatively cold, introduced into the boiler per hour and evaporated. The boiler would hold about 150,000 lb. of water, and

As each stoker would burn about 12,000 lb. of coal per hour, the amount of soot deposited in the soot lock would be about 1 per cent., or 120 lb. per hr. When operating these boilers for long periods of time, a considerable amount of soot would accumulate and seriously interfere with the draft, thus cutting down the capacity and efficiency of the boiler.

Another reason against the adoption of the design shown in Fig. 3 was the difficulty in holding and replacing the tile in the middle bank of tubes should replacement be necessary. A further difficulty was that the method of connecting the rear drum and tube bank to the boiler proper would cause an interruption of the circulation. There being no circulation in the rear bank, this column would be solid water and its density would be that due to its temperature, while the contents of the first, second and third banks, being a mixture of steam and water, would have a less density, causing a lowering

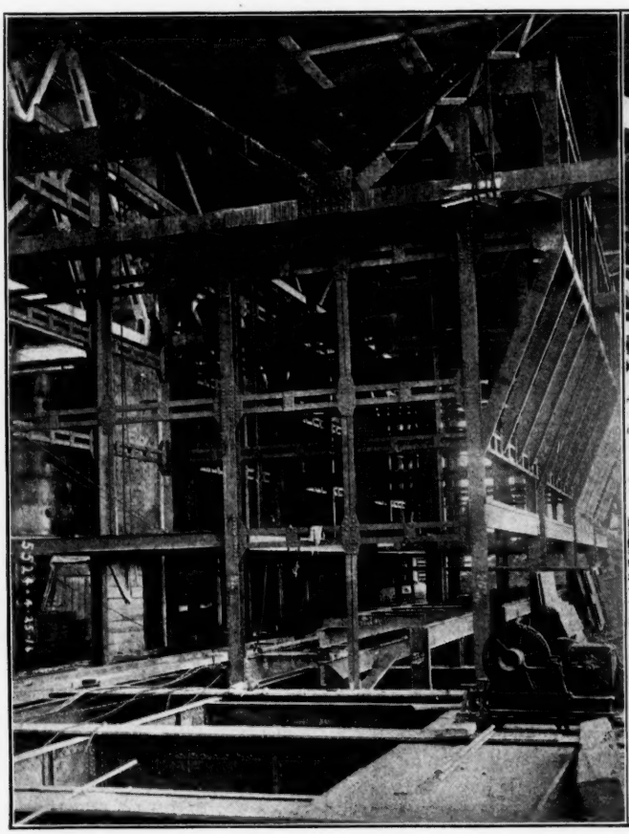


FIG. 5. SHOWING THE STEELWORK FOR THE 2,500-HP. BADENHAUSEN BOILERS

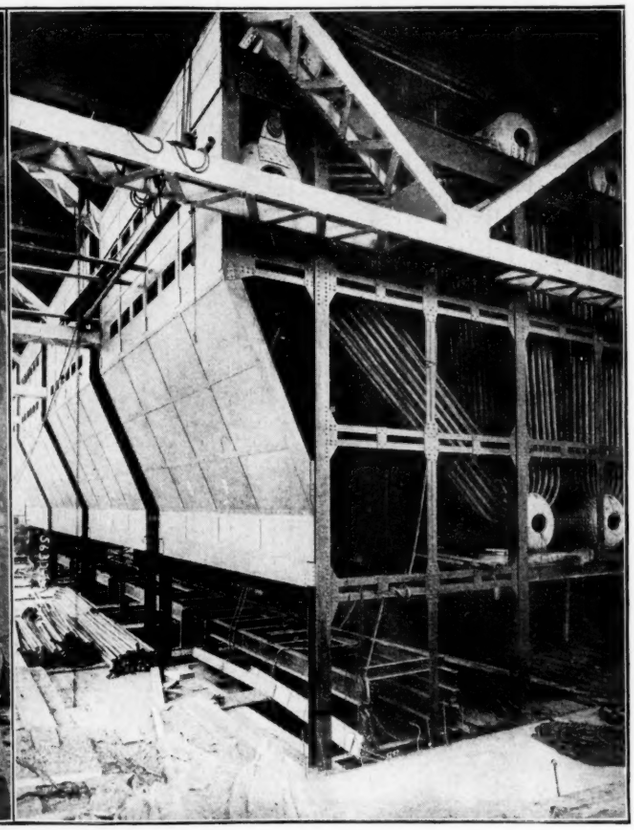


FIG. 6. BOILERS WITH STEELWORK ERECTED, READY TO BE BRICKED IN

all this weight of water, tubes and drums would be subjected to intense heat and varying temperature. Suspending the mud drum from these banks of tubes was out of the question, as the tubes would be liable to crack off. Furthermore, three separate banks of tubes entering the mud drum, as shown on the diagram (Fig. 3A) would mean a greatly increased diameter of the drum with heavier sheets and greater chance of distortion.

A third fault, while not dangerous, was nevertheless one to be considered from an operating standpoint. This is the soot lock shown by the arrow in Fig. 3. Due to the baffling at the mud drum, this soot lock would be at the worst possible place; difficult to remove and obstructive to the operation of the boiler.

of water level in the rear bank and drum. At heavy overloads a serious interruption of circulation would be possible.

Summarizing, the deficiencies in design No. 3, some of which were dangerous and all to be avoided, were: Imperfect suspension of the mud drum, causing tube trouble by cracking the tubes off and strains upon the ligaments in the mud-drum tube sheets; excessively large mud drum; soot lock; inability to repair or replace baffling; no circulation in the rear bank; interference with circulation of the boiler water, and inadequate connections.

In Fig. 4 is shown the design finally adopted and installed. The objects desired and obtained were. (1) Minimum floor space. The boiler has a width of 24 ft.

and a depth of 16 ft. at the floor level. (2) Maximum heating surface in available spaces. The boiler has 25,000 sq.ft. of heating surface. (3) Large furnace volume. (4) No soot locks. (5) Continous unrestricted circulation. (6) Accessibility in the sense of permitting ingress into the setting, so that every tube and every baffle can be touched, cleaned and replaced by the human hands. (7) Good support and suspension. (8) Dry superheated steam at any rating.

The design consists essentially of the boiler proper with an additional feed-water preheating section. Owing to the fact that the heat is absorbed more rapidly the greater the difference in temperature, it is good engineering to preheat the feed water at one stage and bring this feed water into another boiler stage where it is evaporated. The third and final stage is to superheat the steam.

Referring to Fig. 4, the water enters drum No. 6, flows downwardly in the rear bank and enters the forward bank of tubes connecting drums Nos. 5 and 6. The gases flowing from the preceding heating surface touch one half of the tube bank and then the other, and as there is a difference of temperature in each half of the tube bank, there is also a positive circulation owing to such difference. This gravity circulation in the preheating section is an excellent feature.

After the water is heated, it passes through the horizontal tubes from drum No. 6 to drum No. 3, then drops down through the vertical tubes at the left of the bank into drum No. 1, entering from here into the general circulation. From drum No. 3 the steam flows through the tubes at the top of the setting into drum No. 4. All the moisture is thus eliminated, and the steam is slightly superheated. From drum No. 4 the steam goes into a Superno superheater, in which it is expected that a superheat of from 250 to 350 deg. will be obtained.

The stoker is of an extra-heavy Taylor design, the grate surface approximating 21 ft. wide by 11 ft. deep. The steelwork of the boilers was furnished by the Ford Motor Co. The drums for the first four boilers were furnished by the D. Connelly Boiler Co., Cleveland, Ohio. The balance of the work, except the brickwork, including the bending of the tubes, etc., was furnished by Badenhausen Co.'s shop at Norristown, Penn.

These boilers have not yet been placed under steam. Fig. 5 shows a photograph of the steelwork before the drums were installed, and Fig. 6 shows the boilers with the steelwork erected ready to be bricked in.

Since these four units were installed, orders have been received for three more boilers, all of which will be built in the plant of the Badenhausen Co. at Norristown.

Balancers on Three-Wire System

By H. M. Phillips

SYNOPSIS—A description of the three-wire system as operated from two direct-current generators connected in series and how the same system can be obtained from one generator and a balancer set. The operation of these sets is explained and what may be done to overcome some of the difficulties experienced in their operation.

The three-wire system of distribution is undoubtedly the best in cases where the load is composed of lights and motors such as those usually carried in moderate-sized factories or office buildings. The two-wire system may give satisfactory service at 110 volts, but the cost of conductors will be excessive. At 220 volts from 0.25 to 0.5 as much copper will be required and the motor service will be entirely satisfactory, but 220-volt lights are neither economical nor satisfactory. The three-wire system effects a large saving in copper as compared to the two-wire 110-volt system and allows the use of either 110- or 220-volt apparatus.

The original form of the three-wire system is shown in Fig. 1, in which two 110-volt generators *A* and *B* have their armatures connected in series. It is evident that there will be 110 volts between the neutral wire and either of the outside wires, the connection in each case being directly across the terminals of a 110-volt generator. The pressure between the outside conductors will be the sum of the e.m.f. generated by each machine, or 220 volts as indicated. Generally 220-volt motors are used, connected as shown, although 110-volt motors may be used if desired. With lights connected as shown, it will be observed that there are two more connected to generator *B* than to generator *A*, in which case only enough current for two lights will have to come through the neutral wire from generator *B*. Although it is possible to turn out all the lights on one side of the system and have all those connected to the other side burning, a little care in the arrangement will insure that there will always be approximately the same number burning on each side in actual service. The neutral wire, if properly fused, may therefore be of smaller capacity than the outside conductors.

The necessity of using two small generators in place of one large one went a long way toward offsetting the saving of copper in the three-wire system. Consequently a good many plants were installed with a two-wire 220-volt system, in the hope of obtaining satisfactory 220-volt lamps, or as an alternative, connecting two 110-volt lamps in series. Neither idea proved very satisfactory. For a number of years past there have been very satisfactory three-wire generators built (a single machine that will supply a three-wire system). All manufacturers do not build such machines; there are also many cases where 220-volt generators are already installed and it is desirable to change over to a three-wire system. In either case a balancer may be used.

For a permanent installation of any considerable importance it will generally be best to order a balancer built to meet the special requirements of the individual case. Where quick action and low first cost are required, the engineer will frequently be able to utilize a pair of idle motors with very satisfactory results.

The two machines *A* and *B*, Fig. 2, represent two shunt-wound motors with their shafts coupled together and armatures connected in series for use as a balancing set, connected across the terminals of a 220-volt generator. If the two machines are the same in every respect, equal

voltages will be generated in each armature, opposing that of the main line. Being coupled together, they will run at the same speed and in fields of the same strength.

Neglecting the voltage required to overcome the resistance of the armature windings, the e.m.f. generated in each armature will amount to 110 volts, which will be transmitted to the brushes and gives the same conditions of voltage as if two generators were used as indicated in the figure. When the load is balanced, a very small current, sufficient to run the motors at no load, will flow from the positive terminal of the

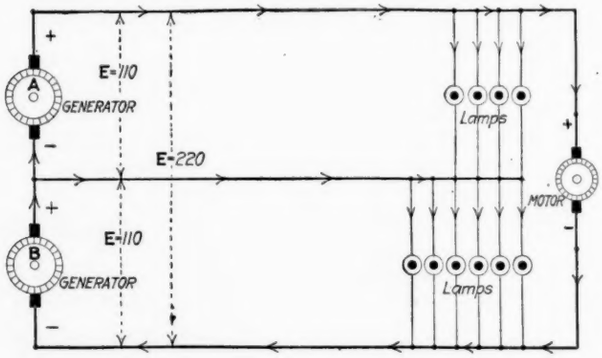


FIG.1

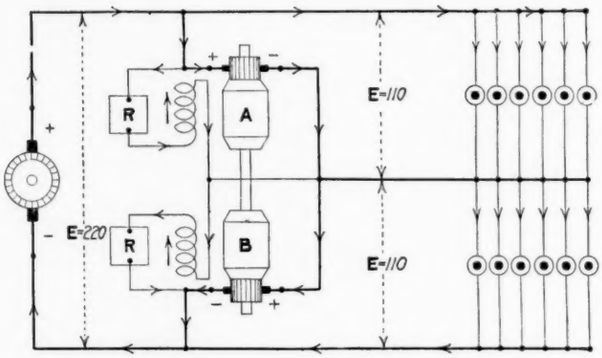


FIG.2

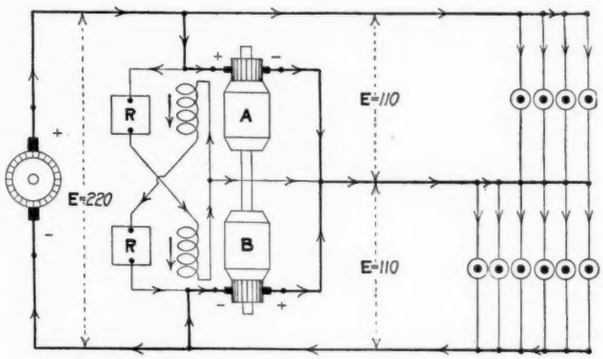


FIG.3

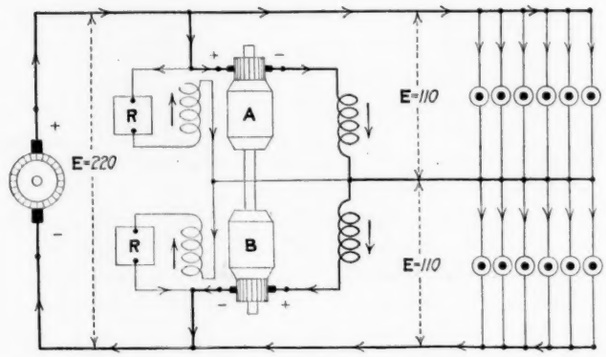


FIG.4

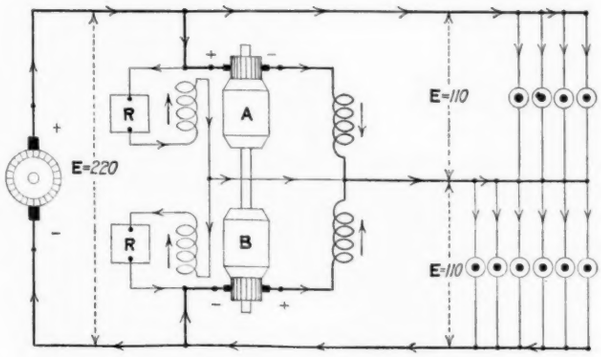


FIG.5

FIGS. 1 TO 5. DIFFERENT CONNECTIONS FOR A THREE-WIRE SYSTEM

generator through machines *A* and *B* back to the negative terminal, as shown.

Assume next that the system is loaded as in Fig. 3. A current will now flow from the positive terminal of the 220-volt generator through machine *A* and pass out along the neutral to supply the demand on the heavily loaded side of the system. This increase of current in *A* gives a stronger turning force and speeds up the balancers. The counter e.m.f. of *B* is almost equal to that impressed upon its terminals, therefore an increase in speed causes it to become a generator driven by *A* and also sends out current through the neutral to supply part of the unbalanced load, as indicated by the arrowheads. The final results are that each armature supplies approximately half the current required by the excess load on one side of the line. As a proper arrangement of the lights will always keep the current in the neutral at a low value, two small motors may serve as a balancer for quite an extensive system.

Even though the two machines have exactly the same rating, accidental variations in their construction will probably cause them to give slightly different voltages. If a field rheostat *R* is introduced in each field circuit, as shown in the figures, the voltage may be adjusted to the proper value.

When balancers are used on a three-wire system, each machine is likely to operate either as a motor or as a generator. Depending on which side of the system carries the heavier load. The voltage generated in the windings of a generator is greater than appears at the brushes, as a few volts are lost in overcoming the resistance of the armature windings. This action is reversed in a motor, where the back voltage added to that overcoming the resistance must equal the voltage applied at its terminals. Applying these facts to the balancer, it will be seen that since both machines have the same voltage in their windings, increasing the load will produce a higher terminal voltage on the motor and a lower voltage on the generator, throwing the system slightly out of balance. With connections as shown

in Fig. 2, this effect will be slightly aggrevated from the fact that a reduction of the terminal voltage of the generator also reduces the current in its shunt field, while the field of the motor is correspondingly strengthened. Connecting the fields as illustrated in Fig. 3 will improve the conditions, for now as load is applied the field of the motor will be slightly decreased and that of the generator increased, which will reduce the change in voltage produced by the load.

If a series-field winding of a small number of turns be added to each machine and so connected that when either machine is running as a motor its field will be differentially connected and when operating as a generator the field windings will be cumulatively connected, the regulation of the sets will be improved. Fig. 4 shows the connection to accomplish this. The arrow-heads indicate that when the load is balanced the direction of the current in the series field winding is opposite to that in the shunt. When the load becomes unbalanced, as in Fig. 5, current will flow from the positive terminal of the main generator through balancer *A* to supply the excess load on the negative side of the system. This will cause the speed of machine *A* to increase, converting *B* into a generator, which will also supply current to the unbalanced load, as indicated by the arrow-heads. It will be seen that the current in the series-field winding of machine *B* is in the same direction as that in the shunt field. In machine *A* the direction of the current in the series-field winding is opposite to that in the shunt. Consequently the voltage will have a tendency to decrease across machine *A* and increase across machine *B*, overcoming the difficulty encountered with the shunt machine, as explained in reference to Figs. 2 and 3. Most all balancers are specially designed compound machines, the series-field windings on compound machines in general use being too strong to be used for this purpose.

Motors designed for 220 volts can be used to form the balancers, in which case it would be necessary to connect the shunt field of each directly across the 220-volt line. The motors will run at half their rated speed; they will therefore have only 0.5 normal horsepower rating and will not give quite as good regulation as 110-volt machines. When it is desired to operate a single 110-volt circuit instead of a three-wire system, the balancer has a decided advantage over a motor-generator set. For instance, to supply 10 kw. at 110 volts by a motor-generator would require a 10-kw. generator driven by a 15-hp. motor; a balancer composed of two 7.5-hp. motors would do the work readily. The balancer would give much the higher efficiency, the total losses being in either case that of the two machines composing the set.

Various odd voltages that might possibly prove useful can be obtained by the use of motors that are designed to run at different speeds. Take two 220-volt motors one of which is designed to run at 1,800 and the other at 1,200 r.p.m. With normal field current and a speed of one revolution per minute, the first would generate approximately 220 ÷ 1,800 = 0.122 volt and the second 220 ÷ 1,200 = 0.183 volt, the sum of the two being 0.305 volt. Connected on the 220-volt circuit the balancer speed would be 220 ÷ 0.305 = 720 r.p.m., giving 720 × 0.122 = 88 volts for the first and 721 × 0.183 = 132 volts for the second. It would not require a very serious weakening of the field to restore the balance, or the higher voltage might be useful for charging a storage battery.

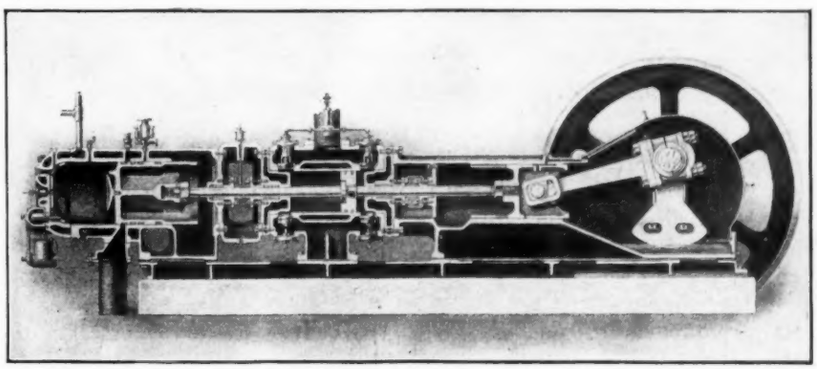
With an 1,800-r.p.m. 110-volt motor connected up with a 1,200-r.p.m. 220-volt machine, the same method of figuring will give line voltages of 55 and 165 respectively. The former might be useful for electric welding or the operation of a searchlight. Assuming that the two machines are designed for the voltages in question and have 100 per cent. efficiency, in order to deliver 10 kw. there must be 10,000 ÷ 220 = 45.5 amp. in the 220-volt circuit, all of which must pass through the 165-volt armature, giving it a capacity of 7.5 kw.; which would also be the capacity of the other armature. This is not a very marked advantage over the motor-generator, where each armature would have 10-kw. capacity. On the other hand, if the same amount of power is required from the 165-volt circuit, the same method of calculation gives 45.5 amp. through the 55-volt armature with a capacity of 2.5 kw. for each armature—a great saving over the motor generator.

When using 110-volt motors in cases similar to the foregoing, care should be exercised that they receive approximately their proper field current; in the case last mentioned the field might be connected across the 165-volt circuit with a rheostat of sufficient capacity to reduce it to 110 volts at the motor.

Fuel-Oil Driven Compressor

To produce an air compressor with a low operating cost and a low first cost, and suited to heavy duty under abnormal conditions but with operating qualities of economy and simplicity, has been the aim of the Chicago Pneumatic Tool Co., Chicago, Ill., in the development of the Class N-SO fuel-oil driven compressor.

The machine operates on low grades of fuel distillates and is guaranteed to run on any mineral oil of 28 deg. Bé. scale or lighter, containing not over 1 per cent. sulphur. There are a number of oils below 28 deg. Bé. on which the compressor will run satisfactorily, depending, however, upon the characteristics of the oil.



SECTIONAL VIEW OF FUEL-OIL COMPRESSOR

The compressor is of the horizontal, straight-line, single-stage type with compressing cylinder bolted to the main frame and closely connected in tandem to the power end. The power cylinder is of the valveless, two-cycle,

low-compression design, as already described in *Power* (see p. 610, Oct. 27, 1914).

The outstanding features of the compressing cylinders are the "Simplate" flat-disk air inlet valves and the discharge valves.

The compressor is made in both single and duplex types. The single compressor comes in six standard strokes, 8, 10, 12, 14, 18 and 21 in. The smaller sizes may be tank-mounted and the larger types set on skids, so they are not confined to stationary requirements.

Handling Coal and Ashes at Grundy Plant

By Henry J. Edsall

SYNOPSIS—A comparatively small modern plant provided with complete coal- and ash-handling equipment. Comparative costs of handling coal in this station and in a simple plant in which the coal is wheeled from a trestle to the stokers and crushed by hand.

Just how large a plant must be before it will pay to install coal-handling machinery is a question on which little definite data are available. Much depends on local conditions, the character of the load and the possible saving in labor over hand operation. The equipment must of course net a fair return on the investment,

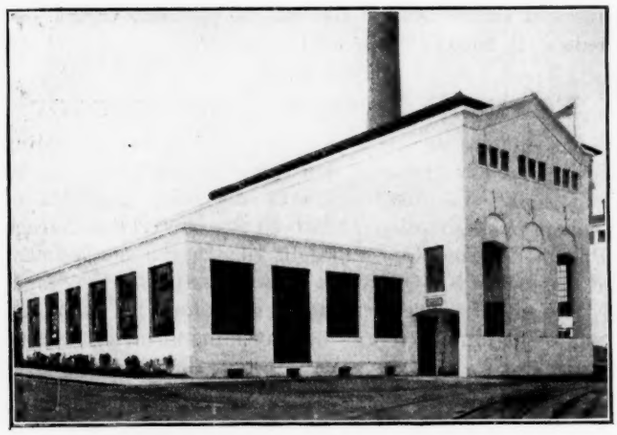


FIG. 1. GRUNDY POWER PLANT AT BRISTOL, PENN.

and each plant in itself is a problem that must be solved on the basis mentioned.

A good example of a comparatively small plant with complete coal- and ash-handling facilities is that serving the woolen mill of the William H. Grundy Co., Bristol, Penn.

In the engine room there are two Corliss engines directly connected to two-phase 60-cycle 220-volt 500-kw. alternators. One engine is a tandem, and the other is a cross-compound. Both exhaust to jet condensers. One of the 125-volt exciter units is belt-driven from the engine shaft; the other is driven by a direct-connected vertical engine at 305 r.p.m.

At one end of the engine room are the pumps and feed-water heater; the latter is of 3,000-hp. capacity and is of the metering type. Two duplex house pumps take water from a reservoir in the boiler room, which is supplied by a near-by canal, and boiler feed is supplied by two outside-packed pot-valve type of duplex pumps. All water used in the power plant is metered. The steam and exhaust lines are placed in the basement, thus relieving the engine room of all piping.

The operating floor of the boiler room is near the ground level, with a basement under the boilers to take care of handling the ashes and flue dust, and 30 ft. 10 in. above the operating floor is a coal-storage bin occupying the entire upper part of the building. The lower chord of the roof trusses is 17 ft. above the storage floor, and the floor of the monitor, where the conveyor runs, is 10 ft. above the bottom chord of the roof trusses. This makes it possible to pile the coal about 27 ft. deep at the center of the building and to store about 5,000 tons. This bin is therefore really a combination active and reserve storage, as the daily coal consumption will probably never run over 100 tons.

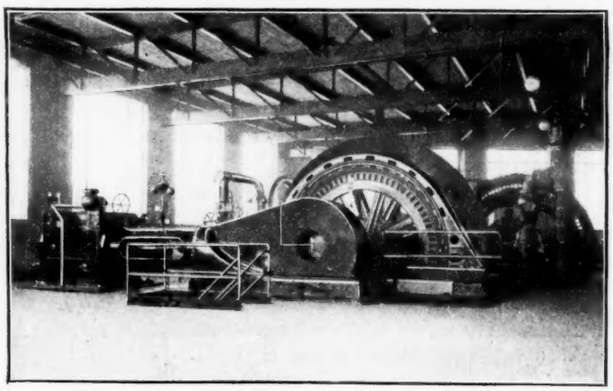


FIG. 2. ENGINE ROOM OF THE GRUNDY PLANT

A Peck pivoted bucket carrier elevates the coal to the overhead bin and transfers the ashes from the hoppers under the boilers to a storage bin outside of the building and over the railway siding. Under this railway siding is a track hopper with a reciprocating feeder and coal crusher and a transfer conveyor which takes the coal from the crusher up a slight incline and spouts it to the carrier. Two rows of gates with spouts under the overhead bin deliver the coal to a traveling weighing hopper from which it drops into the stoker magazines.

The apron conveyor operates at a speed of about 54 ft. per min. and is driven by means of a chain drive from one of the crusher-roll shafts. Its total length is a little over 31 ft. between centers. The carrier is 18x21 in.; that is, the pitch of the chain is 18 in. and the width of the bucket is 21 in. The driving shaft is geared to a motor by a silent-chain drive and spur gears with two intermediate countershafts. The speed of the carrier is 30 ft. per min., and the capacity is 25

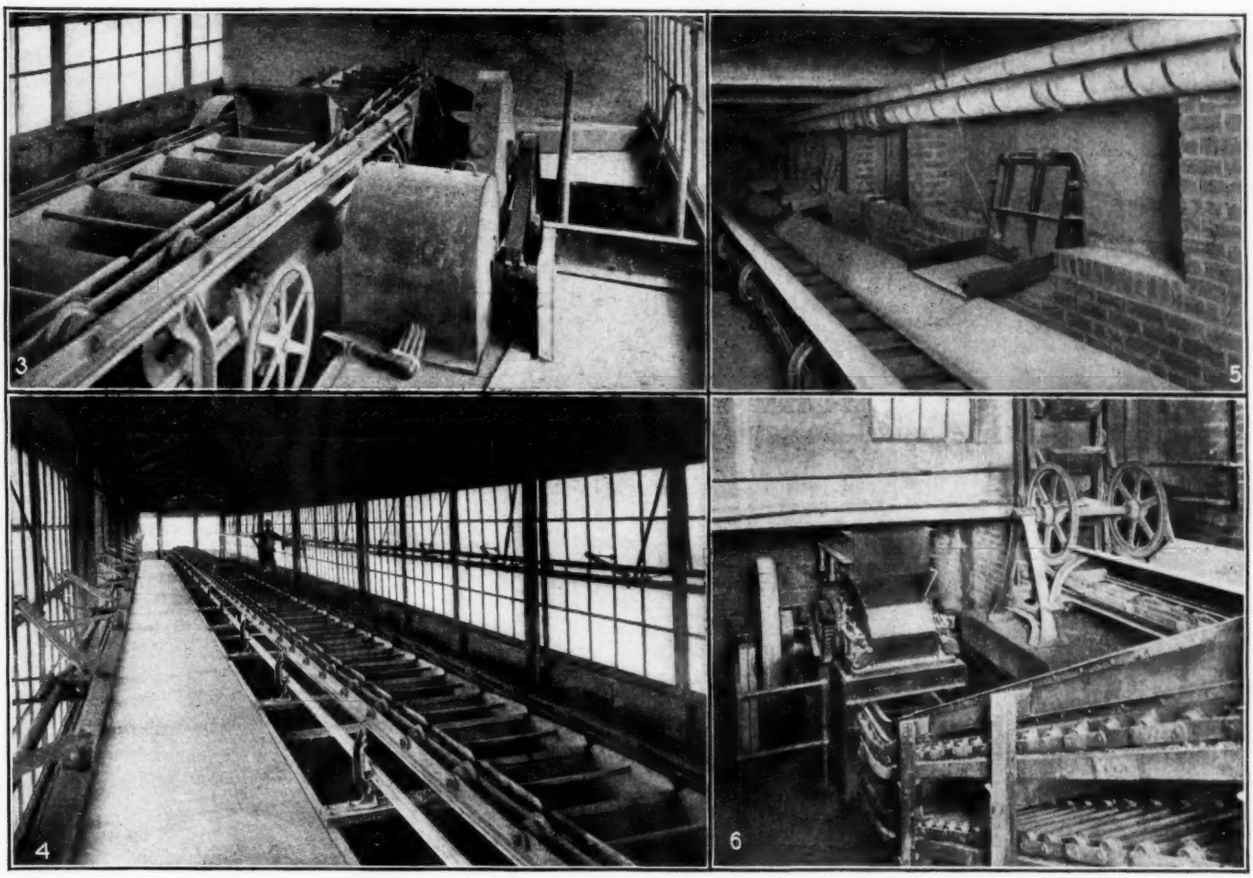
tons of coal per hour. The crusher, feeder and transfer conveyor were designed for the same rate of handling.

The gates on the bottom of the coal bin are operated by levers extending down to within reach from the floor. When a gate is opened, the coal is delivered to the traveling weighing hopper, which has a capacity of one ton of coal. It is electrically propelled along steel angle tracks supported from the floor of the coal bin. There is also a hand chain provided so that the weighing hopper can be moved along the track by hand in case of electrical trouble. After the coal is placed in the hopper, the operator weighs it by means of a scale beam and punches a ticket to record the weight. The coal can then be delivered to the stoker magazines by opening a lever-controlled gate on the hopper bottom.

Murphy stokers are used, the furnaces extending about 9 ft. 8 in. in front of the boilers. The height of the magazines above the floor is about 8 ft. 6 in., and above this a 3-ft. extension makes it possible to deposit considerable coal on top of the magazines. Underneath the stokers there are ash hoppers with gates and chutes delivering to the carrier underneath the boilers. The outlets to the ash hoppers are 2 ft. wide by 18 in. deep. Each is provided with a cast-iron door that swings upward and is held open by a counterweighted wire rope running over a sheave attached to the roof of the tunnel. There are also flue-dust chutes with gates farther back under the boilers, which deliver to the carrier.

The boiler room is arranged for six 402-hp. boilers set in batteries of two each and one additional battery of four 150-hp. boilers now on hand. At present there are only two of the 402-hp. B. & W. boilers installed. These are operated by one man on each shift, and he also looks after the feeding of the ashes to the conveyor. If the boilers were all installed and, say six were in operation, running both day and night, there would probably be three men on the day shift and three men on the night shift to operate the stokers, one man on the day shift to feed the ashes to the conveyor and look after the general care and oiling of the carrier and also to help in unloading the coal, and possibly a cheaper man on the night shift to look after the ashes. The labor for unloading the coal from the railroad cars would naturally come from outside the boiler room.

To make a comparison of what the cost of operation would be with such a boiler room equipped with stokers and also equipped with coal- and ash-handling machinery and overhead bins, and a boiler room equipped with stokers but with a trestle so that the coal could be deposited on the ground and wheeled into the boiler room and shoveled into the stokers, the writer has assumed that the trestle for storing the coal on the ground close to the boiler room would cost in the neighborhood of $5,000 and that the coal- and ash-handling equipment already described, together with a moderate-capacity overhead bin, say three or four days' supply, would cost about $20,000. These figures would of course vary under dif-



FIGS. 3 TO 6. DETAILS OF THE CONVEYOR INSTALLATION

Fig. 3—Upper turn of carrier, showing silent chain drive. Fig. 4—Upper horizontal run of carrier. Fig. 5—Ash hopper gates delivering to carrier. Fig. 6—Crusher and transverse conveyor feeding to carrier

ferent conditions, but would probably be somewhere near an average. He has also assumed that the ordinary laboring man wheeling the coal and ashes would get about $14 a week and that the men who operate the

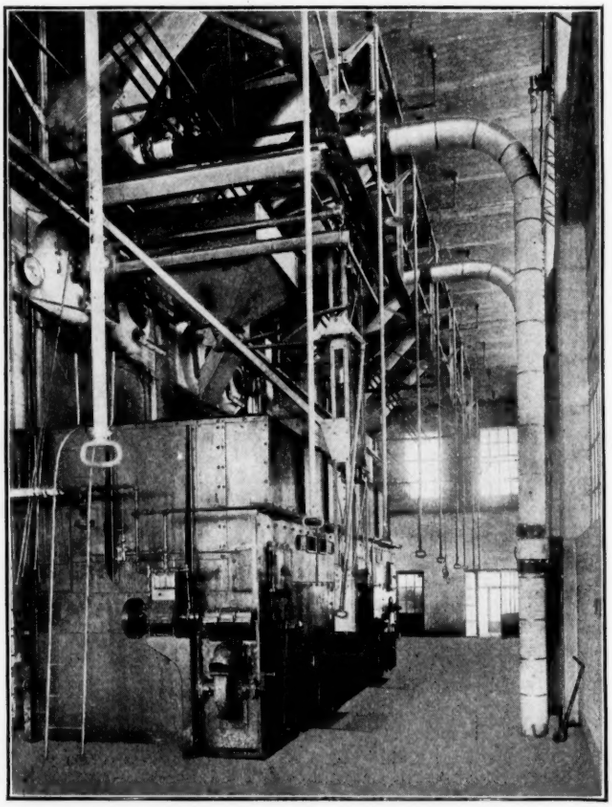


FIG. 7. BOILER ROOM OF THE GRUNDY PLANT

stokers would get $25 a week. Where the coal is wheeled into the boiler room, then broken by hand and shoveled to the stokers, there is an allowance made of two men for wheeling the coal and handling the ashes on each shift and six men on each shift for shoveling the coal to the stokers and operating the stokers for the total horsepower of a little over 3,000 obtained from six boilers running at about 125 per cent. of ratings.

Where the coal and ashes are handled mechanically and fed to the stokers from the overhead bin, there is an allowance of one day man at $25 per week for operating the conveyor and feeding ashes to it and also helping with the coal handling, one night man at $15 per week for handling ashes and three men on each shift for operating the stokers. The amount of coal per year is assumed as 36,000 tons, which is nearly 100 tons per day. The repairs and depreciation are each assumed to be 5 per cent., which may be considered low by some engineers, but if 5 per cent. of the cost is spent each year for repairs on the equipment described, it will certainly last for twenty years, judging from experience with similar equipments. A comparison of the two methods of handling coal and ashes and of feeding the stokers is given in the accompanying table.

COMPARATIVE OPERATING COSTS

Boiler room equipped with trestle, estimated cost, $5,000.

Coal wheeled to boiler room, lumps broken by hand and coal shoveled to stokers.

Coal used per year, 36,000 tons.

	Cost per Year of 365 Days
Unloading coal from cars and trimming, at 3c.	$1,080
Wheeling coal, 2 men days and 2 men nights, at $15.	3,120
Shoveling coal and operating stokers, 6 men days and 6 men nights, at $25	15,600
Repairs, 5 per cent. of $5,000	250
Depreciation, 5 per cent. of $5,000	250
Interest, 6 per cent. of $5,000	300
	$20,600

Boiler rooms equipped with coal- and ash-handling machinery and overhead bin; investment for this equipment, $20,000.

Amount of coal used per year, 36,000 tons.

	Cost per Year of 365 Days
Unloading coal from cars, at 3c.	$1,080
Operating conveyors and feeding ashes to it, 1 man days at $25 and 1 man nights at $15	2,080
Operating stokers, 3 men days and 3 men nights, at $25 per week	7,800
Repairs, 5 per cent. of $20,000	1,000
Depreciation, 5 per cent. of $20,000	1,000
Interest, 6 per cent. of $20,000	1,200
	$14,160
Yearly saving	$6,440

Thus there is shown a saving of over $6,000 per year on an additional investment of about $15,000, and this comparison of machinery equipment is made against a trestle where the unloading is comparatively easy, so that the saving comes simply in the mechanical handling and crushing of the coal, the gravity feed to the stokers and the handling of ashes by machinery. If the mechanically equipped plant was compared with a plant where the coal is shoveled from the cars, in addition to the other hand labor, the saving would show up even better.

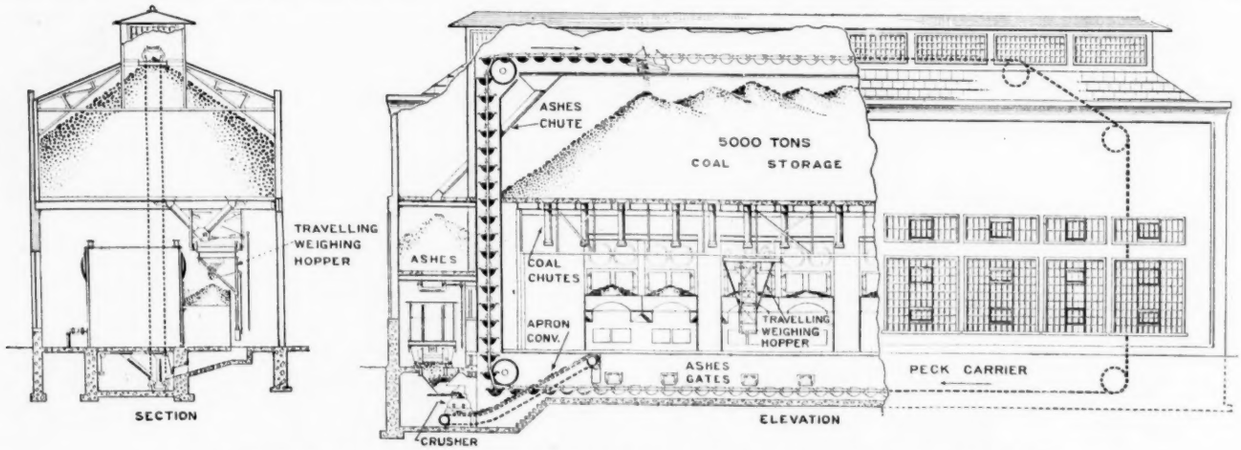


FIG. 8. GENERAL LAYOUT OF THE BOILER ROOM AND COAL-CONVEYING APPARATUS

The allowance of one man per boiler where the feed to the stokers is by hand shoveling may seem too liberal, but it must be remembered that the lumps of coal would have to be broken up by hand, the coal shoveled into the stoker magazines, the doors of which are at the level of a man's shoulder, and then leveled off with a short hoe. This labor would all be in addition to the regular work of operating the stoker, which includes more or less working of the fires. The allowance, therefore, of one man per boiler for handling in the neighborhood of one ton of coal per hour is none too liberal.

On the other hand, where the coal is handled mechanically and fed by gravity to the stoker magazines, the allowance of one man for each two boilers may be more liberal than is required, since one man could operate probably three boilers where they are run at 125 per cent. of rating. Better economies would, however, probably be obtained by having one man handle only two boilers, and therefore the writer has figured this way. If only two men were used for handling the six boilers on each shift, instead of three men, this would make the mechanically equipped plant show up more favorably.

It is safe to say that in a mechanically operated plant using one man to fire two boilers, the fuel efficiency would be enough greater than when operating with one man for three boilers to more than offset the extra cost of labor, and in either case the fuel efficiency would be better than in a plant where each fireman had to shovel coal into the stoker hoppers, as this work is so heavy that the actual working of the fires would be neglected, and they would not be kept in proper condition for efficient operation. This question of fuel economy is an important one, and it has been proved that with poor firing with this type of stoker the boiler efficiency may drop below 60 per cent., but with good firing it is possible to operate at 70 per cent., or even better, this difference in efficiency being equivalent to a saving of 15 per cent. in the amount of fuel used.

It would be safe to count on at least 5 per cent. lower fuel consumption in the mechanically operated plant. On a basis of 36,000 tons of coal per year this would mean 1,800 tons of coal saved, which, figured at a cost of $3 per ton, would amount to $5,400 per year. Another important point in the elimination of the labor of breaking up the coal and shoveling to stokers is that it is possible to get and keep good firemen when the coal is fed by gravity to the stokers, but it is nearly impossible to get such men to heave coal almost continuously into the stoker hoppers. This is being proved constantly by actual experience.

Vacuum Heating Systems

By Charles L. Hubbard

SYNOPSIS—A general description of the three, so-called, vacuum heating systems in use at present, together with the methods of producing and controlling the degree of vacuum for best results.

Vacuum heating systems vary more or less in detail of design and construction, but they may all be included in three groups, as follows:

First, the "air-line" system, in which a partial vacuum is applied to the automatic air valves only, by means of a small pipe line connecting them with the vacuum pump. The result is a rapid and positive removal of air from the radiators regardless of the steam pressure in the system. Steam is supplied to the radiators in the usual manner, and the condensation flows back to the boiler or receiving tank by gravity. The vacuum does not extend into the radiator, but simply to the air valve. This condition, however, makes it possible to maintain a steam pressure below that of the atmosphere because no greater pressure is required to force the air out. Air-line systems are well adapted to tall buildings having comparatively small ground areas and correspondingly short runs of horizontal piping. In other words, the conditions must be suited to a gravity return.

Second, the return-line vacuum system, in which the partial vacuum is applied to the main return from the heating system. In this case the usual air valves are omitted from the radiators and the return lines are fitted with special automatic valves which allow the passage of air and water but close against steam. Here a vacuum exists in the return piping up to the radiator return valves, but the pressure in the radiators, as in case of the air-line system, is independent of the vacuum. This system is adapted to any type of building, but is especially effective in connection with plants covering considerable area and having long runs of horizontal pipe insufficiently graded to secure gravity drainage, and considerably smaller return pipes may be used.

The third group includes a number of arrangements where the entire system, including boiler, radiation and piping, is under a uniform pressure somewhat below that of the atmosphere and varied within certain limits, thus regulating the heating capacity slightly with varying outside temperatures.

Steam Pressure Carried—Although both the air-line and return-line systems are called vacuum systems, it does not follow that a high or even a moderate vacuum is carried in the radiators. As a matter of fact, it is customary to maintain a steam pressure in the heating system approximating that of the atmosphere. Under ordinary conditions a free exhaust will produce a back pressure of 1 to 2 lb. gage, depending upon the size and form of the exhaust passages and the number of bends in the length of the exhaust pipe. A well-designed heating system of the vacuum type should reduce the back pressure to zero gage, or less. If it is desired to limit the pressure in the heating system to zero gage, the back-pressure valve is left free and the reducing valve in the live-steam supply is set to open at the minimum pressure.

If still less pressure is to be carried on the heating system and the exhaust exceeds the demand, a reducing valve is placed in the exhaust supply pipe set to maintain the required pressure. Figs. 1, 2 and 3 show the pipe connections for carrying any desired pressure on the heating system.

These three arrangements each maintain the predetermined pressure automatically, and the pressure may be varied by changing the adjustments of back-pressure and reducing valves. In the return-line system the condensation together with the air is handled by the vacuum pump, the mixture being discharged into a receiving tank.

Vacuum for air-line systems is produced by a steam ejector for a small plant or an air pump in larger plants. An ejector with duplicate connections is shown in Fig. 4. The exhaust from the ejector is usually turned into a feed-water heater to utilize the contained heat. Vacuum for return-line systems should be only sufficient to insure a prompt removal of air and water from the radiators and to lower the steam pressure on the heating system the desired amount. A high vacuum tends to produce a leakage of steam into the return through the automatic valves and causes a part of the condensation to flash into steam if the difference in pressure between the radiator and return pipe is too great, and the presence of steam in the return is a waste due to the necessity of condensing with a water jet. Ordinarily a vacuum of about 2 in. is carried at the most remote radiator. This may require a vacuum ranging from 3 or 4 in. up to 20 in. at the pump, depending on the length of run. Under average conditions, however, this will not exceed 8 or 10 in.

Size of Pump—Makers of vacuum pumps give ratings in equivalent square feet of direct radiation. In making an estimate on this basis 1 sq.ft. of indirect radiation should be taken as 2 ft. of direct, and 1 sq.ft. of hot-blast surface, in connection with a fan taking air from out of doors, should be taken as equivalent to about 6 ft. of direct. Catalog ratings are for average speeds and lengths of run. If the return mains are of excessive length and contain many bends, a larger size of pump should be used.

H. C. Russell gives in the *Metal Worker*, July 28, 1911, the following method for determining the size of vacuum pump for a given heating system that takes into account both the square feet of direct radiating surface and the number of automatic return valves.

In the table the "factors" given in the last column are equal to 100 times the number of automatic valves plus the square feet of radiating surface.

Example: A vacuum heating system having 30,000 sq.ft. of direct radiation and 500 automatic return valves on radiators and drips. What size of pump will be required from the table?

"Factor" = 30,000 + (500 × 100) = 80,000. The nearest size of air end corresponding to this is 12x12 in., which has a "factor" of 82,400. Referring to manufacturers' catalogs, we find that a 12x12-in. pump has a rated capacity of 34,400 sq.ft. of radiation, which corresponds fairly well for two different methods of arriving at the proper size. The steam cylinders are made suitable for the pressures available for operating the pump.

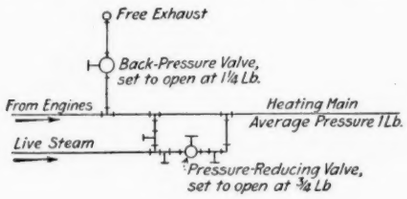

Free Exhaust
Back-Pressure Valve, set to open at 1¼ Lb.
From Engines
Heating Main
Average Pressure 1 Lb.
Live Steam
Pressure-Reducing Valve, set to open at ¾ Lb

Fig. 1

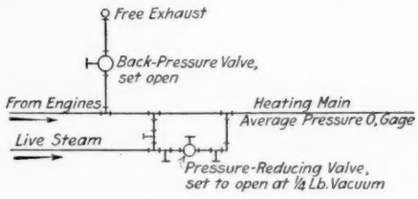


Fig. 2

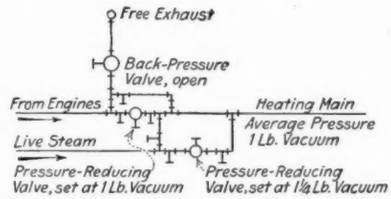


Fig. 3

FIGS. 1 TO 3 ARE DIAGRAMS OF PIPE CONNECTIONS FOR DIFFERENT PRESSURE CONDITIONS

DIRECT-ACTING STEAM-DRIVEN VACUUM-HEATING SYSTEM PUMPS

Diameter of Steam Piston, In.	Diameter of Air Piston, In.	Length of Stroke, In.	Factor
4	4	5	6,830
4	4	8	8,000
4	5	5	10,680
4	5	8	12,500
4½	5½	8	15,125
4½	6	8	18,000
5	6	10	19,400
6	7½	10	30,600
6	8	12	36,620
8	9½	12	49,000
8	10	14	60,250
10	12	12	82,400
10	14	16	122,500
12	16	16	161,270
16	18	20	220,006

Temporary vacuum systems operating on a gravity return are apt to be sluggish in the morning when steam is first turned on with maximum condensation, and there is more or less short-circuiting, causing some radiators to remain cold and resulting in considerable water-hammer and surging in the mains.

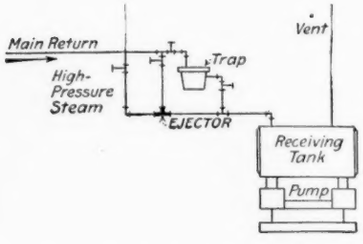


FIG. 4. EJECTOR CONNECTION

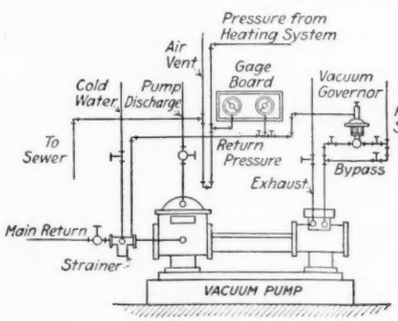


FIG. 5. VACUUM GOVERNOR

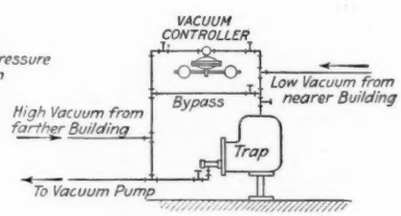


FIG. 6. VACUUM EQUALIZER

The writer has seen difficulties of this kind overcome by placing a small high-pressure ejector in a bypass of the main return near the receiving tank. And by its use for a short time in the morning the system is cleared of air and condensation, after which it will circulate freely for the rest of the day. This arrangement is shown

in diagram in Fig. 4. If the return empties into a vented receiver, no changes will be necessary except making the pipe connections, but a closed receiver must have a valved vent pipe to be opened while the ejector is in use, and this should be closed under normal conditions.

Regulating the vacuum will depend upon the type of pump used. With the direct-acting steam-driven pump the degree of vacuum to be maintained is controlled by the tension of the coil spring above the diaphragm on the vacuum governor, which is adjusted by the hand-wheel at the top. The method of connecting the regulator with the pump is shown in diagram in Fig. 5.

Electrically driven pumps are controlled by a diaphragm-operated knife-switch, which automatically starts and stops the motor to maintain the desired vacuum.

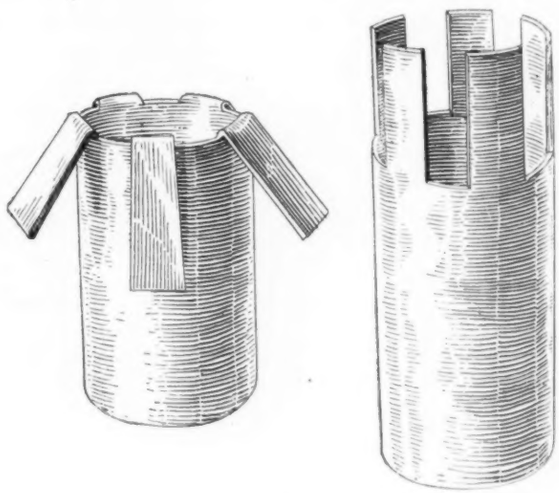
Equalizing the Vacuum—Sometimes the radiation is located in two or more widely separated groups, and the returns are connected with a single vacuum pump. It is evident some will have a considerably higher vacuum unless means are taken to equalize it in the different return lines. This may be done by the arrangement shown in Fig. 6; the vacuum in the nearest group is reduced and condensation trapped into the higher vacuum line.

Vacuum Systems in Live-Steam Heating—In heating systems not connected with a power plant, the use of a vacuum system is not so necessary, as a sufficient pressure may be carried to reach the farthest radiators and force out the air. However, there are cases, especially in large buildings, where circulation is sluggish and there is more or less water-hammer and a return-line vacuum system may be employed to advantage.

To Catch Loose Pump Valves

By F. F. Sengstock

To prevent pump discharge valves from getting away through the pipe when they chance to come loose, I use a sort of strainer made of copper or brass tubing of about



OBSTRUCTION TO THE PASSAGE OF LARGE OBJECTS

half the size of the discharge pipe and about six inches long, slit and flared out as shown in the illustration. When this is put into the discharge pipe, no large object such as a valve can get by it.

Visits of Inspector Brown--XVII

By J. E. Terman

SYNOPSIS—Brown and the Chief continue their discussion of the Code rules for steam-boiler safety valves as affecting the discharge area. The Chief also compares the Code rules with the Massachusetts rules on safety valves, and tables are given showing the lift of flat- and bevel-seated valves as specified by the two rules. The Chief maintains that basing the safety-valve capacity on the grate surface is not logical and goes on to prove his case

Although Brown had been up late the night before, studying the problem connected with the determination of the capacity of safety valves, he started to work early in the morning so that he might finish his inspections and have plenty of time to spend with the Chief in the afternoon, for he knew that there was a lot to the subject of how to determine the proper size of safety valves for a boiler. He had reached the office by noon and had practically finished writing his reports when the Chief returned from lunch. As soon as Brown finished his reports, he went into the Chief's office and said: "Well, Chief, I think I know why $L \times 0.707$ in the Code formula is used in place of the expression $\sqrt{\frac{L^2}{2}}$ (L being the lift of the valve in inches), which I used in getting the effective lift. I worked over that problem half of last night, and early in the evening I ran upon a snag that got me away off. I later on found that $L \times 0.707$ was just the same as $\sqrt{\frac{L^2}{2}}$, for this equals $L\sqrt{\frac{1}{2}}$, and the square root of $\frac{1}{2}$ is 0.707. I would have been perfectly satisfied when I found that out, if it hadn't been for the fact that I found the method we used to get the effective discharge area for a 4-in. safety valve was not right.

"See here, Chief, I have sketched a valve with a 45-deg. beveled seat" (producing Fig. 2) "and instead of A times the circumference of the valve seat being the effective discharge area of the valve it is A times the circumference of a circle whose diameter is ($2B$) more than D."

"Well, that is not important," said the Chief. "Although the way you have figured out the effective area is correct," he continued, "this extreme refinement in calculating the effective discharge area is not generally used or required in safety-valve calculations. The reason that $L \times 0.707$ is used in the Code formula instead of the expression that you obtained under the radical sign is for convenience, because this figure 0.707, which is the sine of an angle of 45 deg., may be obtained directly from a table. If you will look up your tables of natural trigonometrical functions, you will see that it is a simple matter to get this figure. The code formula does not take

into account the slight additional effective diameter of the outlet as given at the center of dimension A in your sketch" (see Fig. 2), said the Chief.

"You, of course, understand that if the lift of the valve was large with respect to the bevel, the same method of obtaining the effective discharge area would not hold good."

"Yes, I found that out last night, and I intended to speak to you about it. Here is a sketch I drew to illustrate the point that I intended to make," said Brown, producing Fig. 3.

"However, valves made up to the present time do not have such high lifts in relation to the length of the level on the seat."

"Now, Chief," said Brown, "I thought a lot about this question last night, and I suddenly tumbled to the fact

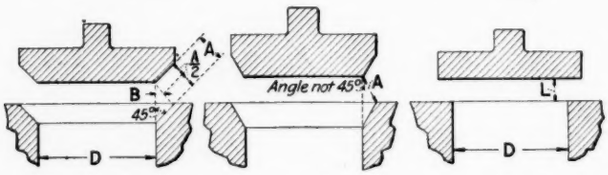


Fig. 2 Fig. 3 Fig. 4

FIGS. 2 TO 4. BEVELED AND FLAT-SEATED SAFETY VALVES

that with a flat-seated valve lifted a given amount the discharge area would be considerably greater than would be the case with a bevel-seated valve; why doesn't the Code take care of that?"

"Brown, I am afraid that you have not read your Code carefully. If you will look at the bottom of the table for the discharge capacities for safety valves with 45-deg. beveled seats, you will see that a footnote has been added to the table, which states that the discharge capacity of a flat-seat valve of a given size and lift may be obtained by multiplying by 1.4 the discharge capacity as given in the table for a bevel-seated valve of the same diameter and lift.

"You see," continued the Chief, drawing Fig. 4, "the discharge area with a flat-seated valve is $3.1416 \times D \times L$, and not $3.1416 \times D \times L \times 0.707$, as for the bevel-seated valve, and multiplying the second expression by 1.4, or to be exact by 1.4144, would make it equal to the first expression."

"Gee, Chief! I can see where the bevel-seated valves for Code boilers become a thing of the past."

"Yes, Brown, and you can also see where the low-lift valve comes into great disfavor with the fellow who has to pay the freight."

"I will bet a dollar, Chief, that no one in Henderson's shop noticed whether those valves they put on the boilers that Casey's foreman was talking about had flat or beveled seats."

"Well, I guess you are right, Brown. But they will all get onto the ropes after a while; and when they do, the fellow who is selling the high-lift flat-seated valve won't need any drummers on the road, for all he will have to do is to send his price list to the boiler maker and have it arranged so that the boiler maker will understand that he is buying so much steam-relieving capacity for a dollar, and the orders will take care of themselves.

"We are now ready," said the Chief, "to compare the Code rules on safety valves with the other rules on the same subject and see if the Code seems to require more valves than necessary. To begin with, we had best take the Massachusetts rules for safety valves, as they seem to be the ones that your friend Casey is particularly interested in. The Massachusetts rules give a table to guide the boiler manufacturer in the selection of the size of valves required, and they also give a formula for the purpose of selecting the proper-size valves, where the conditions exceed those in the table. This formula is likewise used in determining the values given in the table. The formula is $A = \frac{W70}{P} \times 11$, in which W and P represent exactly the same quantities as in Napier's formula, but A in the Massachusetts rule is the nominal valve area and not the effective discharge area, as in Napier's formula. Now, Brown, by rewriting the Massachusetts formula so as to get it into the same form as Napier's formula we have $W = \left(\frac{A}{11}\right) \times \frac{P}{70}$, and it is seen at once from this arrangement that the discharge area in the Massachusetts rule is assumed to be one-eleventh of the nominal valve area, without considering what the probable lift of the valve might be or whether it has a beveled seat or a flat seat. It will no doubt interest you to know just what lift would be required for a valve so that its effective discharge area would be one-eleventh of its nominal area."

"Sure, Chief," said Brown, "and I think I can figure that out myself. The nominal area would be $0.7854 \times D^2$, where D is the nominal valve diameter; and since the Massachusetts rule assumes one-eleventh of this area as the effective discharge area, $\frac{0.7854 \times D^2}{11}$ would be the discharge area assumed. With a flat-seated valve where L is the lift, the effective discharge area would be $3.1416 \times D \times L$. Making this expression equal to the first and solving for L will give the valve lift required, or $\frac{0.7854 \times D^2}{11} = 3.1416 \times D \times L$, or $L = 0.0227 \times D$. If the valve was a bevel-seated one," continued Brown, "$\frac{0.7854 \times D^2}{11} = 3.1416 \times D \times L \times 0.707$, or $L = 0.0321 \times D$, would give the lift required to equal one-eleventh of the nominal valve area."

"You are right, Brown. I did a little figuring myself on this problem some time last year, and here is a table that I made up, showing the amount of lift that safety valves would be required to have in order to discharge the steam that the Massachusetts rules assume that they will discharge. I also placed under them for comparison the lifts specified in the Code table."

FLAT-SEATED VALVES

	Valve Diameters in Inches				
	2	2½	3	3½	4
Lifts assumed by the Massachusetts rules, in inches....	0.045	0.057	0.068	0.079	0.091
Intermediate lifts as specified in the Code.....	0.06	0.06	0.08	0.09	0.10

BEVEL-SEATED VALVES

	Valve Diameters in Inches				
	2	2½	3	3½	4
Lifts assumed by the Massachusetts rules, in inches....	0.064	0.080	0.096	0.112	0.128
Maximum lifts as specified in the Code.....	0.07	0.08	0.10	0.11	0.12

"You can see, Brown," said the Chief, "that the relieving capacities credited to bevel-seated valves by the Massachusetts rules would require that the valves lift as high as

and in the case of the 4-in. valve higher than, the maximum permitted under the Code rules; and in the case of the flat-seated valves the lifts would be required to be almost as high as those given in the Code for intermediate lifts."

"Why, Chief, I am surprised at that," said Brown. "I have always been under the impression that safety valves have been constructed with lifts as low as, or lower than, those specified in the Code as intermediate lifts."

"They probably have been made that way in the past, Brown; but they will not be in the future when the boiler makers all get onto the fine points in purchasing safety valves, so that they will purchase relieving capacity and not merely safety valves. If you will look at the table of safety-valve capacities in the Massachusetts rules, you will see that at the top of each column are given the assumed values for W and P that have been used in calculating the tabular values in the column; and there is also given a value for A, which is the nominal valve area required for each square foot of grate surface under the assumed values given to W and P.

"For example, in the column headed 'Over 100 to 150 lb.' W is stated to equal $\frac{160}{3,600}$ the 160 being the number of pounds of steam that 1 sq.ft. of grate surface is assumed to evaporate in an hour's time. This is divided by 3,600 to get the amount evaporated in a second. The value of P, you will observe, is stated to be 140, which is practically the absolute pressure corresponding to 125 lb. gage, 125 being the average of the range in pressures from 100 to 150 lb. The value of A is given as 0.244, which is the value given for the area by the Massachusetts rule when the above values for W and P are substituted in the formula.

"You will notice that there is no regular system used in getting up the table in the Massachusetts rules. The value of P is taken as the absolute pressure corresponding to the highest gage pressure in the columns giving the value area required up to 100 lb. gage pressure; the average gage pressure is the one used above this point, and an absolute pressure corresponding to a gage pressure of 225 lb. is used for all pressures over 200 lb., all of which makes difficult a satisfactory comparison with a logical rule like the one used in the Code.

"Since the Massachusetts safety-valve rule is based on grate area and the Code rule on heating surface, it will be necessary to assume a ratio between the grate area and the heating surface in order to compare the two. As you know, Brown, this ratio varies greatly in general boiler practice. I believe it would be about right," said the Chief, "if it is assumed that in horizontal return-tubular boilers the average ratio of grate to heating surface is 1 to 35, and for water-tube boilers 1 to 55. Anyway, a comparison on these two ratios will give us a good idea of how the two rules will compare in practice. It will be necessary to stick to one rate of evaporation per square foot of grate surface! and since 160 lb. is used in the Massachusetts table for pressures from 50 to 150 lb. gage—a range of pressures that covers the usual conditions under which the average plant is operated—that value for rate of evaporation will be used.

"The minimum valve area required under the Code rules is based on the number of feet of heating surface and at an assumed rate of 5 lb. of water per square foot per hour for fire-tube boilers, and 6 lb. per hr. for water-tube boilers. Under the assumed conditions for ratio of grate to heating surface the table in the Massachusetts rules would be based on an evaporation of 4.57 lb. of water per square foot of heating surface where the ratio was 1 to 35, and 2.91 lb. where the ratio was 1 to 55."

"Why, Chief, that seems to be just the opposite to the way it should be; all the plants I visit that have a high ratio between the grate and heating surface are generally equipped for forcing the boilers, and they usually evaporate more steam per square foot of heating surface than the plants with lower ratios between the grate and heating surface."

"That is true, Brown, and it only goes to show that basing the safety-valve capacity on the grate surface is not logical. To continue with our comparison," said the Chief, "here is a table that I made up, showing the amount of heating surface taken care of by a few different sizes of valves under the code rules and the Massachusetts rules. Since the Massachusetts rules make no distinction between the relieving capacity of flat- or bevel-seated valves or between high- or low-lift valves, it seems perfectly proper to use the high-lift flat-seated valves in applying the Code formula in making the comparison; the boiler maker may always purchase this kind of valve if he specifies it. It will be assumed that the maximum allowable working pressure is 125 lb. for the fire-tube boilers and 150 for the water-tube boilers, for these pressures may be said to represent everyday practice in plant operation with such equipment.

FIRE-TUBE BOILERS
Heating Surface Cared for by One Valve

	Valve Diameters in Inches				
	2	2½	3	3½	4
Code	600	860	1,266	1,650	2,060
Massachusetts	450	705	1,013	1,380	1,800

Ratio of grate to heating surface, 1 to 35; gage pressure, 125 lb.

WATER-TUBE BOILERS
Heating Surface Cared for by One Valve

	Valve Diameters in Inches				
	2	2½	3	3½	4
Code	590	841	1,263	1,621	2,016
Massachusetts	708	1,108	1,590	2,175	2,835

Ratio of grate to heating surface, 1 to 55; gage pressure, 150 lb.

"You, of course, understand, Brown, that the Code does not permit the use of one valve alone where the size must be in excess of 3 in., and these tables are merely for the purpose of showing the relative nominal areas necessary under the assumed conditions."

"I am surprised at those results," exclaimed Brown. "The Code actually requires less nominal valve area for the average horizontal return-tubular boiler than is demanded under the Massachusetts rules."

"Yes, that is so, Brown; but the Code requires more nominal valve area where the ratio between grate and heating surface is high and water-tube boilers are used, which is as it should be. Well, Brown, it is now 4:30, and I have to get off quite a lot of mail. This comparison of safety valves will have to be put off until some other time; but if you will come in again, I will try to show you how some of the other safety-valve rules in general use compare with the Code rules. You should not forget in studying these tables," said the Chief, "that the values given for Code requirements are for the minimum safety-valve capacity; and if the conditions under which a boiler is operated are such that the pressure, with this minimum valve equipment, would rise more than 6 per cent. above the pressure at which the valve was set, additional safety-

valve capacity would be needed under the Code rules. However, it will only be found necessary to have additional valve capacity in plants where the boilers are so installed that they may be forced very hard, for the minimum capacity for fire-tube boilers, as required by the Code rules, will care for conditions up to about 250 per cent. of rating, where the rating is on a basis of 10 sq.ft. of heating surface per boiler horsepower, before the pressure will rise more than 6 per cent. above the point at which the valves are set."

"Well, Chief, there are not many horizontal-tubular boiler plants that will need additional valve area above the minimum amount required," said Brown.

Effect of Water Upon Carbon

By Glenn Warren

Owing to the numerous claims for devices upon the market designed to remove carbon or prevent its formation by the injection of water or steam into the combustion chamber of an oil or gas engine, the writer determined to make an investigation. Experiments were made under conditions approximating those existing in the cylinders of an internal-combustion engine, and at the same time the apparatus was so arranged that the action could be easily observed.

For this purpose a thin-walled steel tube, about 1¼ in. diameter and about 12 in. long was supported so that steam from a small boiler could be forced in at one end and under the last 3 in. from the other end a couple of blow-torches were placed.

It is a well-known fact that incandescent carbon at a temperature of about 1,800 to 2,500 deg. F. will decompose steam into hydrogen and carbon monoxide according to the equation $H_2O + C = CO + H_2$.

To note the effect of this upon a deposit of carbon, cylinder oil was placed in the steel tube and boiled until it no longer gave off inflammable vapors, and in this way a thin layer of carbon similar to the deposit on the inside of a cylinder was obtained. Upon passing steam for a short time through the tube, a small portion of which was heated to a bright-red heat with a blow-torch (about 1,800 deg. F.), the carbon upon the inside of the hottest part of the tube was found to have been entirely consumed, but that on the part of the tube that did not reach a red heat was apparently unaffected.

Upon throwing water in the liquid condition upon the heated carbon on the inside of the tube and allowing it to boil vigorously, a much larger portion of the carbon appeared to be removed or loosened to such an extent that the least breath of air would blow it away.

To verify this observation a small amount of cylinder oil was distilled to dryness upon a sheet-iron plate without access to the air and as nearly as possible realizing the conditions in the cylinder where the oil is heated in an atmosphere containing a large percentage of inert gases such as carbon dioxide and nitrogen. This sheet iron coated with carbon was then heated not quite to redness and treated with water. After the water had evaporated the carbon was in every case loosened from the plate so that it could easily be blown away with the breath.

Kerosene, reputed to be such a good carbon remover, was tried similarly and not only failed to remove any carbon, but actually left a deposit of its own, for it distilled in the same way that the cylinder oil had.

One of the chemicals now used to run through the carburetor of an automobile motor was also tried, but gave no better results than pure water.

Thus to sum up, steam removed the carbon that had reached an incandescent temperature, but did not affect the carbon deposit at a lower temperature; while water in the liquid state applied to a hot surface coated with a deposit of carbon loosened the deposit to such an extent that it could easily be blown away.

The greater part of the carbon in an engine cylinder, however, never under normal conditions reaches a temperature high enough to become incandescent; if it did, serious trouble from preignition would ensue. The carbon must, however, be deposited from the burning charge in a finely divided condition, and this carbon before its deposit would be incandescent.

From this the conclusion must be drawn that steam in any form will not remove the greatest part of the carbon deposit in a motor, or that part which does not reach incandescence, but it would, if mixed with the charge, oxidize the finely divided particles of incandescent carbon and prevent the formation of carbon deposits. Therefore, those devices on the market designed to mix a small amount of moisture or steam with each charge as it enters the cylinder should prevent the formation of carbon, if effective in introducing a sufficient amount of steam, but would not remove the carbon already there. On the other hand, the introduction of water into the cylinders in the liquid state should loosen the carbon deposit to such an extent that it could be easily blown out the exhaust. The action of the water seems to be that it gets in between the carbon particles and, upon being suddenly vaporized by the heat, loosens the deposit.

This is nothing new. In fact, the writer saw water used in this way several years ago, but had never heard an explanation of its action or seen any experimental proof of its effectiveness. Here, as in many other things in the gas-engine industry, practical experience has gone ahead of science and theory. Many instances in practical work seem to bear out the conclusions reached.

Upon examining a cylinder having removable heads in which the gasket has leaked so that upon standing idle, water from the jackets will seep in, it will be found that the carbon deposit is loose and not nearly so heavy as in the other cylinders of the same engine where the water has not entered. Again, if water alone be run through the carburetor of a hot engine, clouds of carbon will issue with the exhaust gases.

Effect on Power of Engine

The effect that the steam or moisture will have upon the power developed and the economies obtained is greatly exaggerated. The claim is made that the water decomposes into its elemental constituents, hydrogen and oxygen, and that the oxygen thus liberated combines with the carbon in the fuel, thus producing greater power. It is true that at the high temperature of the initial part of the explosion, before the gases have been cooled by expansion, the water would decompose in part. But since the heat evolved during a chemical change is always exactly equal to the heat that is absorbed when the action is reversed, and since when oxygen and hydrogen unite to form water heat is given off, it follows from this law that when water is decomposed heat will be absorbed; therefore the mixture of gases would be cooled by the decomposi-

tion of the water, and thus power would actually be lost. The oxygen formed would unite with any free carbon and burn it to carbon dioxide, thus securing more complete combustion of the carbon, with cleaner cylinders as a result. At the same time, if the mixture were a little lean—that is, if there were an excess of oxygen present—the hydrogen liberated at the higher temperatures would recombine with the oxygen when the gases reached a temperature betwen 1,800 and 2,200 deg. F. Owing to these two facts, a portion of the heat used in decomposing the water would be recovered, but at a part of the cycle where it could be utilized less efficiently.

Vibration in Steam Turbines

By H. A. Fisher

Before the advent of the steam turbine in the modern power station, vibration was not a serious consideration, in fact was practically unknown. In the reciprocating engine with its low speed any lost motion or misalignment made itself known as a knock or pound, while in the steam turbine with its high speed and delicate balancing the knock and pound becomes vibration. It is the purpose of this article to set forth some of the cases of vibration that are commonly observed.

Revolving parts improperly coming in contact with the stationary parts will cause vibration. While this is not a frequent occurrence, it is one that will do the most damage and therefore, when suspected, no time should be lost in making an examination to see if there is such contact and if so to remedy it at once.

Faulty grouting under the bedplate is another dangerous source of vibration. The proper mixture and mixing of the grout is important, for no matter how much care is exercised in placing the grout, it will not be satisfactory if it has not been thoroughly mixed in the right proportions; a mixture that is too rich (contains too much cement) will shrink a great deal in setting, while one that is too lean (contains too much sand) will crumble. A grout of equal parts of cement and sand, thoroughly mixed dry and wet down to the consistency of a thin batter and promptly poured, will give good results when care is taken to eliminate the following causes of poor grouting: Freezing, drying out too fast, too little time allowed for the grout to set before starting the machine, grout becoming soaked with oil which will cause it to crumble, and failure to provide for the escape of air from under the bedplate when the grout is being poured. Vibration due to faulty grouting and the movement of the bedplate on the foundation can usually be felt throughout the entire turbine and remains constant at all loads. This vibration can sometimes be stopped or considerably reduced by driving iron wedges under the edge of the bedplate at several points, taking care not to drive them too hard, as the bedplate may be sprung and the alignment of the machine disturbed. The only permanent remedy is to remove the old grout, level the machine up and grout it in again. The top of the foundation should be made rough so that the grout may bind and the foundation should be thoroughly wet down just before the grout is poured.

Turbines supported on I-beams or set on floors supported by I-beams should be grouted with lead, as this will absorb the vibration and prevent its transmission to other machinery and to the building. The final leveling of the bedplate should be done after the turbine and generator have been placed on it and secured.

Bearings that have too much journal clearance—that is, too much clearance between the shaft and the bearing—cause vibration. Such vibration is of a more or less local nature; while it may be felt throughout the machine, it is more noticeable at the bearing or bearings that are loose and is usually more noticeable when the machine is running with a light load and in alternators when the field current is off, becoming less as the load increases or the field magnetism becomes stronger holding the rotor in a more fixed position. Feeding more oil to the bearings will sometimes reduce the vibration.

Journal clearance should be measured with a feeler gage or determined by pinching a lead wire between the top half of the bearing and the shaft and afterward measuring its thickness with a micrometer. This clearance should be about 0.008 in., for a few thousandths more will sometimes cause vibration. In case the journal clearance is found to be correct and the vibration continues, the bearing shell should be examined to see if the lining is loose or the bearing is not rigidly held in the pedestal or pocket in which it rests, as any clearance between the bearing cap and shell will allow vibration, which will gradually become worse.

Clearance between the bearing cap and shell is sometimes caused by inaccurate fitting in the shop, or by some foreign material between the machined faces or flanges of the bearing cap and pedestal preventing the cap from being drawn down on the bearing shell, or by the practice of putting a heavy coating of thick shellac or other substance on this joint to prevent leakage of oil. In one case the writer found that a paper gasket had been put in, causing a clearance of 0.006 in. between the cap and the bearing. Ascertaining the clearance between the cap and bearing shell is accomplished in the same way as journal clearance. The bearing should be placed in its regular position and several pieces of small lead or fuse wire placed on the machined surface of the bearing shell so that when the bearing cap is placed in position and the bolts tightened, the soft wire will be squeezed down to the thickness of the clearance between the bearing cap and the shell. It is best to start with a small wire and if no impression is made on it, try a larger one. After getting an impression of the clearance, it should be measured with micrometer calipers, and a thin brass or copper shim of the same thickness should be put in. If the shaft is low at the bearing the shim should be placed under the bottom half of the bearing shell, but if the shaft is level the shim should be placed on top between the shell and cap.

With high-speed turbines it is necessary that the rotor be perfectly balanced. This is done in the shop, but during shipment or in course of erection, or even after the turbine has been put in operation, the shaft may be sprung, throwing the machine out of balance. If it is not sprung more than, say 0.01 in., the rotor may be

balanced by weights in the drum or disks of the turbine, but this should be done by someone who has had considerable experience in this kind of work, for weights in the wrong place may do considerable damage. Turbine rotors may be thrown out of balance by a leaky throttle allowing steam to enter when the turbine is standing still. This heats the rotor and the casing unevenly, and the rotor will run out of true and vibrate when starting. The machine should not be left standing with the steam blowing through, and it is best to start it rotating slowly while warming up.

Scale and mud in the blades or buckets will also unbalance it and should be removed as soon as possible. Dirt on the rotor of the generator will sometimes cause vibration, therefore the generator field and armature should be blown and cleaned frequently.

The coupling between the turbine and generator should be examined for loose bolts, and in machines having flexible couplings the fingers or pins of the coupling should be examined for wear, as a shoulder worn on the pins may cause the shaft to have endwise travel and there will be a sort of bumping vibration that will be more apparent at light loads. In this type of coupling the oilways should be kept open so that the oil may get between the pins.

The generator air gap should be equal, and the rotor and stator should be axially centered with each other so that there will be no end thrust. Loose bearings on the governor or oil-pump shaft may cause vibration. The steam and exhaust piping should be provided with expansion joints and be well supported, so as not to impose strains on the turbine and disturb its alignment. The running clearances being small, care should be exercised when the bearings are disturbed or adjusted in any way, so that the proper clearance is maintained between the stationary and revolving parts.

In conclusion, there is nothing mysterious about the steam turbine or its ailments, so that any of the ordinary ailments and adjustments are well within the scope of the engineer.

Belt-Conveyor Operating Data

By John D. Morgan

SYNOPSIS—Data relative to size and amount of material handled, belt speed, power requirements, cost of belting and maintenance cost per ton of coal conveyed.

In view of the fact that few operating engineers are familiar with the operating characteristics of belt conveyors, this article was made up in curve form so that the operating data would be available at a glance. Some of the data used have been given to the public before, but in such a way that few could understand.

Belt conveyors are divided into two groups, horizontal and incline, or a combination of both, and each group has its own calculations.

Fig. 1 shows the quantities of coal that can be handled by different sizes of belt at various speeds. In Fig. 2 the amounts of different materials that can be handled by a 36-in. belt conveyor at different velocities are given. The maximum sizes of material for different widths of belt, consistent with good operation, are plotted in Fig. 3.

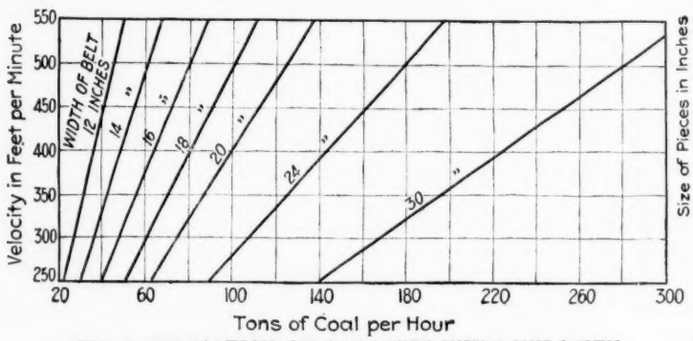


FIG. 1. VARIATION OF CAPACITY WITH VELOCITY OF BELT

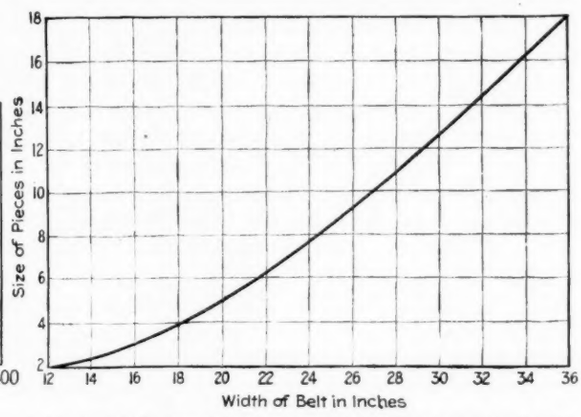


FIG. 3. MAXIMUM SIZE OF PIECES TO BE HANDLED BY BELT CONVEYORS

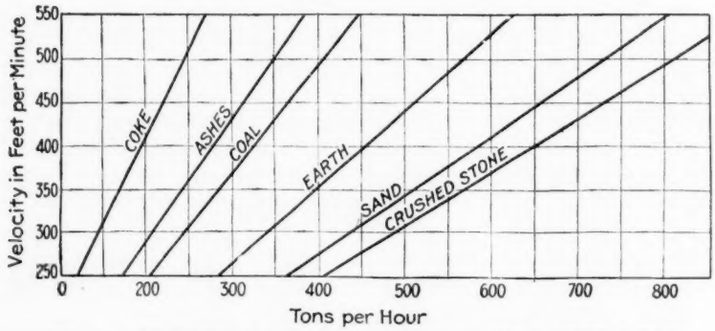


FIG. 2. CAPACITY OF 36-IN. BELT TO HANDLE DIFFERENT MATERIALS

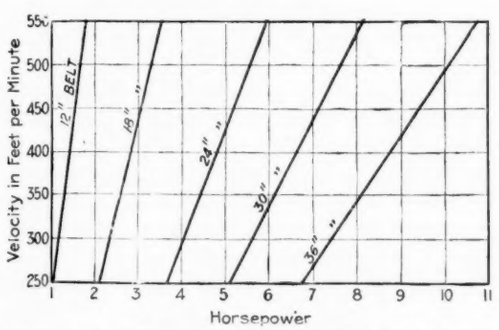


FIG. 4. POWER REQUIREMENTS OF 100-FT. C. TO C. LEVEL CONVEYORS

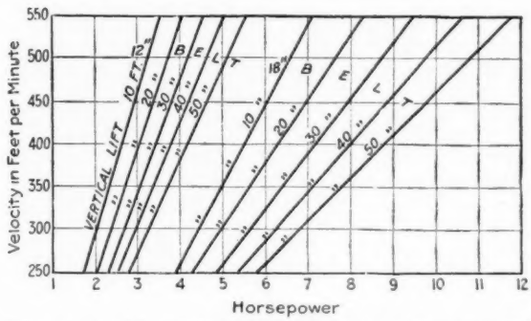


FIG. 5. POWER REQUIREMENTS OF 100-FT. C. TO C. INCLINE CONVEYOR—ONE MOVABLE TRIPPER

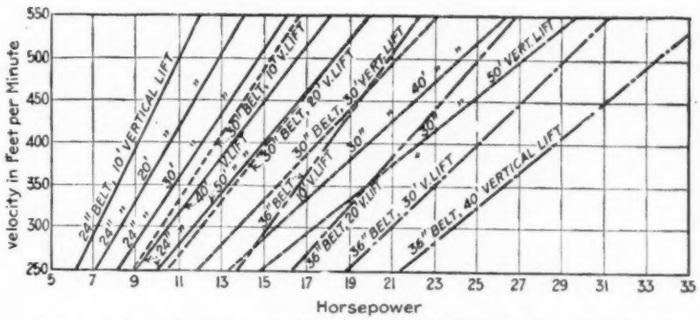

Velocity in Feet per Minute
Horsepower
24" BELT, 10' VERTICAL LIFT
24" " 20' " "
24" " 30' " "
24" " 40' " "
30" BELT, 10' V.LIFT
30" " 20' V.LIFT
30" " 30' V.LIFT
30" " 40' " "
30" " 50' VERT. LIFT
36" BELT, 10' V.LIFT
36" " 20' V.LIFT
36" " 30' V.LIFT
36" " 40' VERTICAL LIFT
36" " 50' VERT. LIFT

FIG. 6. POWER REQUIREMENTS OF 200-FT. C. TO C. INCLINE CONVEYOR—ONE MOVABLE TRIPPER

As will be noticed in these curves, the capacity of a belt conveyor varies with the velocity and the width of the belt, and as the capacity changes so do the power requirements of the conveyor. Fig. 4 shows the power requirements of a 100-ft. center to center level conveyor with one movable tripper, for various belt sizes and velocities. Only by actual test can the power requirements of any particular conveyor be found, yet if the formula given is used, a good approximation is obtained. When using this formula it must be remembered that allowances for gear and friction losses must be made. For a level conveyor

$$Horsepower = \frac{KLD}{1{,}000}$$

For values of K see Fig. 8. Throughout the article K is a constant varying with different sizes of belt and the specific gravity of the material handled, L is the load in tons of 2,000 lb. per hr., D the distance from center to center of the conveyor in feet, and H the vertical height in feet that the material is to be lifted.

Figs. 5 and 6 show the power requirements of a 200-ft. center to center incline conveyor with one movable tripper, for various widths of belts, velocities and vertical heights. If the same allowances are made as were assumed in the calculation of level conveyors, the following formula will give good results for an incline conveyor:

$$Horsepower = \frac{KLD + LH}{1{,}000}$$

Often it will be found that it is desirable to change the size of the driving pulley. In Fig. 9 a curve is given showing the belt sizes of rubber-surfaced pulleys for different sizes of belt.

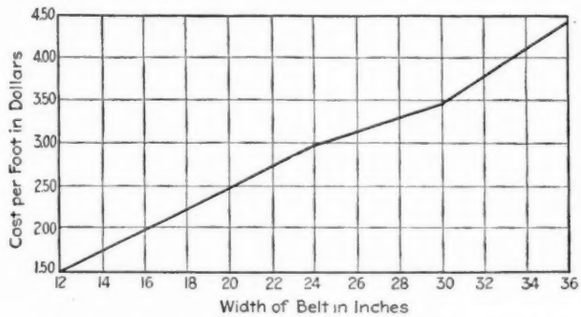


FIG. 7. COST OF SIX-PLY FIRST-QUALITY BALATA CONVEYOR BELTING

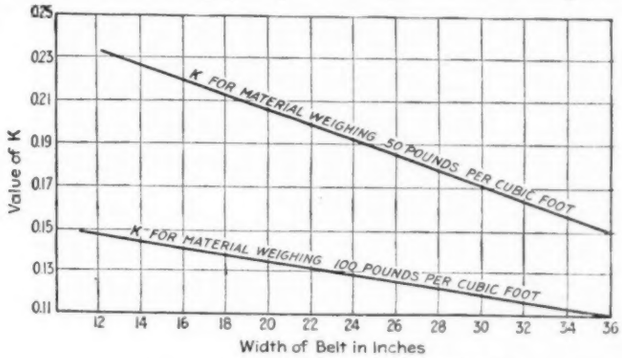

Value of K
K FOR MATERIAL WEIGHING 50 POUNDS PER CUBIC FOOT
K FOR MATERIAL WEIGHING 100 POUNDS PER CUBIC FOOT
Width of Belt in Inches

FIG. 8. VALUES OF K IN HORSEPOWER FORMULA

An important operating question is belt speed, which depends upon belt size and stress, for it has been found that 20 lb. per ply is the maximum allowable stress consistent with good belt service. Fig. 10 shows the maximum advisable speeds as obtained by a series of tests.

The matter of cost now enters in, and as a rule the first question is, "What is the right kind of belt to use?" This question has to be decided by the material to be conveyed. The writer is of the opinion that a balata belt of the first quality will outlast any other for use on soft coal and under various weather conditions. It

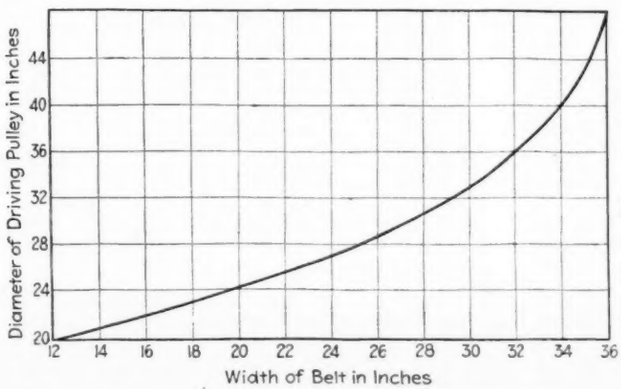


FIG. 9. ADVISABLE SIZE OF DRIVING PULLEY

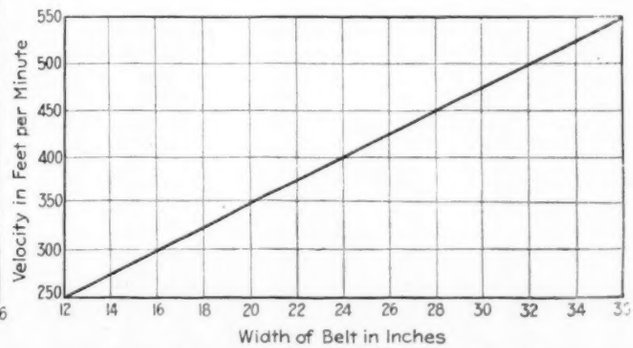


FIG. 10. MAXIMUM ADVISABLE BELT SPEED

is true that the price is higher, yet the wearing quality will more than make up for the difference. Fig. 7 shows the cost of varying sizes of balata belt of the first quality.

The final consideration is the maintenance cost per ton of coal conveyed. This item will vary from year to year, but a good average cost will be found to be about 0.247c.

New Recording Thermometer

A new type of recording thermometer for temperatures as high as 800 deg. F., or 425 deg. C., is being manufactured by the Brown Instrument Co., of Philadelphia.

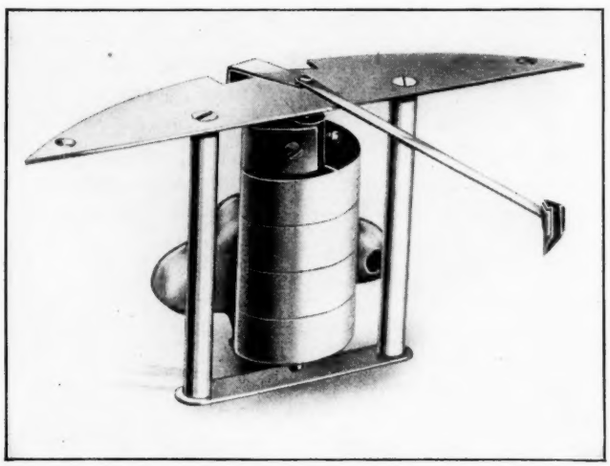


FIG. 1. HELIX AND RECORDING ARM

This instrument, which embraces a number of original features, operates on the principle of the expansion of gas with a change in temperature. A bulb of copper containing nitrogen gas under pressure is connected to a recording instrument by a small copper tube protected by flexible steel tubing.

The recording instrument, Fig. 2, has a helical spring, somewhat similar to that used in pressure gages, and the expansion of the gas in the bulb exerts a pressure that is conveyed by the capillary tube to the helix, which expands proportionately. This helix, Fig. 1, is directly connected to a recording arm which marks on the record chart. This type of instrument can be furnished with tubing of sufficient length to enable the recording gage to be placed at a maximum of 100 ft. distant from the point where the temperature is measured. This permits of its application in numerous processes where it is desirable to keep a constant record of the temperature on a chart. Some of the improved features in this new type of instrument follow: The clock which revolves the chart is mounted directly on the front plate on which the chart revolves, which insures alignment of the clock and chart plate. The clips that hold the chart in position are mounted on the door, so that when the latter is swung aside the clips are automatically swung away from the chart, permitting its easy replacement without interference. A device is furnished which raises the chart pen from the chart automatically when the door is opened and frees the pen automatically when the door is closed.

This instrument is made also in indicating form, Fig. 3, where desired, to indicate the temperature on a dial instead of recording it on a chart. It is furnished with a number of different types of bulbs, either with threaded connection for insertion in mains and pipes or with lead coating to withstand chemicals and acids.

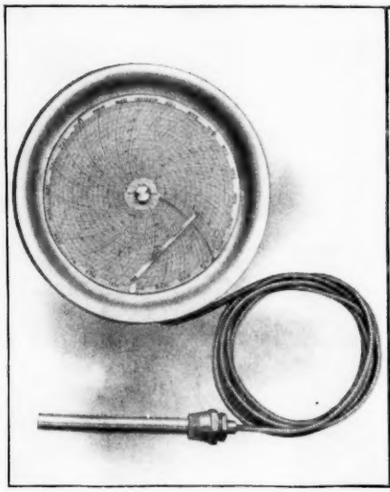


FIG. 2. RECORDING GAGE

FIG. 3. INDICATING GAGE

Fast Overhauling Work

The Commonwealth Edison Co., of Chicago, recently performed what must be considered a feat for speed. The 30,000-kw. turbo-generator at the Northwest station was shut down at midnight on a Saturday for its annual cleaning and overhauling, which includes opening, inspecting, cleaning, renewing worn turbine blades and replacing practically the entire auxiliary water-handling system of turbine and pumps. The condenser had also to be cleaned, and about one thousand tubes removed and replaced. This was done and everything replaced and the machine made ready for service within seventy hours.

The turbine unit measures 60 ft. in length, 15 ft. in height and 19 ft. in width. The total weight, including the condenser, is 1,182,000 lb., the low- and high-pressure turbine weighing 477,000 lb. There are ten single high-pressure stages and two low-pressure stages. The turbine is rated at 45,000 hp. and operates at 1,500 r.p.m.

Steam is furnished through a 20-in. header at 250 lb. pressure and superheated to 625 deg. Of the steam-admission valves, 18 in number, 14 are used up to full load and admit steam to the upper half of the first stage, while the other 4 are used for overloads.

The condenser is interesting because of its size. It is of the two-pass surface type and contains 11,000 tubes of 1 in. diameter each, constituting a cooling surface of 50,000 sq.ft. The cooling water in the condenser weighs 65 tons. Fifty-two thousand gallons of circulating water is passed through the condenser per minute, requiring for this purpose a 650-hp. Curtis noncondensing turbine which operates at 1,500 r.p.m., directly connected to a 48-in. double-suction centrifugal pump working against a head of 15 ft.

Editorials

Steel Electrical Conductors

The ever-increasing use of copper in the various industries, especially in electrical work, and the enhanced cost of this material, along with the fact that the supply is exhaustible, have created a demand for a substitute. Aluminum has been used to some extent, but in many respects it has the disadvantages that copper has and in some cases is inferior. Steel seems to be the one material that offers the most promising substitute. In this country only a small amount of attention has been given to the electrical properties of steel as a substitute for copper. In Europe, however, considerable has been done along this line, particularly in Germany. The output of Germany's copper mines is much less than her needs, and being isolated from the rest of the world by the war, she has been forced to find some substitute for this metal. The emergency has been met to a large extent by the use of iron and steel. Electrical machines have been rebuilt, and the design of new ones changed, substituting iron and steel for copper wherever possible. The same thing has been done in the wiring of power houses, for transmission-line cables and feeders, and in the wiring of homes and industrial plants. In this way great quantities of copper have been released for other purposes. It seems reasonable that the knowledge gained in constructing electrical machines and transmission and distribution systems with a minimum amount of copper will influence the construction of this apparatus in the future.

It does not, however, require adverse economic conditions to make it possible for steel wire to compete with copper in many cases as an electrical conductor, as shown by an abstract on "The Use of Steel Conductors for Transmission Lines," published elsewhere in this issue. One of the chief uses of steel as an electrical conductor is in high-voltage lines designed to transmit a small amount of power where, on account of the mechanical strength, it is not possible to use an economical amount of copper. In this particular case iron conductors have shown a marked saving over copper. Steel has also been used for long spans in transmission lines where it was impossible to design a copper conductor of sufficient mechanical strength. This latter problem has also been met by using a copper-clad steel wire, combining the conductivity of copper with the tensile strength of steel.

A peculiarity about steel is that its effective resistance is much higher to alternating current than to direct current. This is on account of the steel having a low resistance to the magnetic flux. It has been found that this difficulty can be overcome by the proper spiraling of the various wires that make up the cable. It is pointed out in the abstract that it is as essential that a steel cable for alternating current be properly stranded and spiraled as it is for the core of an armature or transformer to be laminated. The increase in the effective resistance of a steel conductor to alternating current may in many cases be used to advantage for limiting the effect of various disturbances in the line. It may prove more economical in certain cases to protect lines against short-circuit surges with steel conductors than with current-limiting reactances.

From the data available, it appears that the chief use of steel conductors is on branch lines where the economical size of copper conductors would not have the required mechanical strength; but in all cases steel conductors will be as cheap as copper if not cheaper, although this in many cases is offset by the additional cost for poles and insulators required for the extra weight of the steel conductor. Nevertheless, it would appear that with the cost of copper increasing to almost prohibitory prices and with more definite data at hand on the properties of steel as an electrical conductor, it will find a constantly increasing economical field of usefulness in the electrical industry.

Unreasonable Enforcement of Inspection and License Laws

Power has many times emphasized the fact that the only warrant for governmental supervision of or interference with the operation of steam boilers or other power plant is the preservation of the public safety. When the true significance of conservation comes to be realized, when prices are fixed by cost plus a fair profit instead of by the necessity of the buyer and the control of the seller, the advisability of interfering upon economic grounds may be recognized, but as yet economic waste is regarded as a personal matter not warranting governmental attention except in time of war or special stress.

The limit to which any action under an inspection or license law may go therefore, is measured by this standard and determined by this consideration: "Is it essential to the public welfare or safety?" An engineer's examination and license law must not be perverted to conserving the situations in any city or state for citizens of that political division, by denying the privilege of examination and license to outsiders. There are such laws, but they may be defied with impunity for they would be declared unconstitutional in any court. An engineer must not be refused a license because he cannot design a triple-expansion engine or explain the derivation of hyperbolic logarithms, for such knowledge is not essential to the safe operation of a power plant. A boiler-inspection department must not be too fussy about unessential details, or it may find itself discredited when its case comes to trial. Here are a couple of cases in point:

A young man having served a term in a subordinate position in a large station obtained a third-class license and a situation where he was in charge of a small plant. He took hold with intelligent interest, improved the condition and performance of the plant and was getting along nicely. One of the things which he induced the owner to do, however, was to have the cylinder of the engine rebored, and this was his undoing. The enlarging of the diameter raised the horsepower of the engine slightly

above that covered by his license, and the department refused to let him continue in charge or to examine him for a higher license because he had not run a year in that grade.

A city adopted an ordinance decreeing that no boiler should thereafter be installed within its borders that did not conform to the standard of the A. S. M. E. A boiler built to the standards of Massachusetts and Ohio (which differ from that of the A. S. M. E. only in unessential particulars from the standpoint of safety) was refused admission and had to be returned to the builders after lying for weeks upon the car. There was no contention that the use of the boiler would have been inimical to the public safety or welfare; it simply did not have the stamp of the A. S. M. E. upon it and the ordinance required that it should.

We have urged and continue to urge the adoption of license and inspection laws. We have emphasized the desirability of uniformity in such laws and advocated uniting upon the A. S. M. E. Code. We should like to see every state and other department adopt this code as its standard of excellence, but all laws should be so framed as to admit of common sense in their application. It is such unreasonable interpretations as these that the antagonists of inspection and license laws fear, and that are their best weapons in opposing their adoption.

Departmental Co-operation

It is not uncommon in manufacturing plants to find lack of coöperation between department heads and the engineer in the use of the products of the power plant. The superintendent and his foremen, while closely watching and keeping down manufacturing costs, frequently disregard all the rules as known and cultivated by the engineer regarding the careful use of steam, power and electric light. These things may be considered too trivial since the power costs in the majority of cases form only a comparatively small part of the total cost of the manufactured product; but it must be remembered that profits are now made on smaller margins than formerly, and if steam is allowed to blow uselessly through a process kettle, if machines run idle or with belts and bearings too tight, consuming excessive power, and lights are allowed to burn when daylight is ample, the annual waste may run into three or more figures. It is, indeed, disheartening to the engineer while putting forth every effort to effect savings, some on the verge of being petty, to see elsewhere great waste of the very element he has endeavored to conserve.

In most large concerns the department heads are assembled at intervals for conference and consultation. How often the engineer is in on these conferences does not appear, but we venture to say the instances are few. Would not a well-prepared report on the cost of steam, electricity and horsepower together with the probable amount of each that is accounted for in the output, with a liberal margin for unavoidable waste, balanced against the plant's output, be the means of bringing points of economy, and incidentally the engineer, to the attention of the management to the benefit of all concerned?

Too great results need not be expected from a single attempt, and one should not become disgruntled if no tangible recognition is vouchsafed. Each report should leave an opening for another until the desired end is accomplished. Reports and suggestions should not be made to appear as criticisms, but rather to convey information as to the state of affairs and how dollars may be saved. A trial of the plan may prove a surprise all around—not the least to the engineer himself—and an analysis of a given situation and the preparation of a report are sure to be worth while whether the report is enthusiastically received or not.

Recognizing the Human Factor

Numerous items in the press just now bring out in a forcible manner the present-day movement and the necessity of employer and employee getting together for a better mutual understanding. This subject, although so frequently encountered, can hardly be overdone, for probably at no other time in the history of the world—certainly not in American history—have conditions been comparable with those of the present.

In the nature of things, when large business and combines are built up, employer and employee are set apart to a greater extent than in the days when they knew each other as Bill, Sam or Henry, or as an extreme mark of courtesy the employer was addressed as Mr. somebody instead of the less formal. Nevertheless the feeling was the same—that of approachability. The employer was some *body* instead of some *thing* and the employee more than a serial number on a payroll.

To supplement the personal touch there is a determined effort on the part of many of the larger manufacturers to improve the conditions that came with "big business" by organizing welfare movements. It is considered a paying business enterprise for the employer and not a philanthropy, but this does not detract from its value to the employee. Rather, it is an advantage, for no self-respecting person likes to be considered an object or recipient of charity.

All effort on the part of the employer must, however, be supplemented by effort and coöperation on the part of the employee to take advantage of his opportunities and improve himself. These opportunities are more numerous and made more available than ever before. "A long pull, a strong pull and a pull all together," in this as in all other worth-while movements, will accomplish much.

Speaking of remote control, the London post-office tube railway connects Paddington and Whitechapel, and is six and a half miles long, all tunnel. There will be no men on the trains, which will be electric and controlled from a distance. That motor outfit in the cellar, which we start and stop from upstairs, begins to look simple, after all.

The Swiss Society of Steam Boiler Owners has recently reported on an exhaustive investigation into autogenous welds for steam boilers, and the report confirms the opinions of engineers generally that, everything considered, such welds should not be used where high pressures are employed and where riveting is not unreasonably difficult.

That high rates of driving are not detrimental to a boiler provided it is accompanied by proper supervision needs no better proof than the fact that the Interborough Rapid Transit Co. has a record of fourteen tube renewals a year out of sixty-four boilers.

Correspondence

CO_2 Recorder in Small Plants

Mr. Priefer's inquiry in the issue of Aug. 1, page 178, raises the interesting question, "What is the smallest plant that can afford a CO_2 recorder?"

I suggest the following formula: The saving in the plant must be greater per year than

$$C\left(R+\frac{1}{Y}\right)+\$150$$

where

C = Cost of the recorder;
R = Value of money (interest rate);
Y = Durability of the recorder in years.

For example, suppose the cost of the recorder is $300, the interest rate 6 per cent. and that a recorder will last 10 years. Then

$$\$300\left(0.06+\frac{1}{10}\right)+\$150=\$198 \textit{ per year}$$

The $150 per year is to cover the cost of chemicals and taking care of the recorder. It would therefore appear that a saving of 41c. per day for 365 days per year would make the investment in a recorder "just come out even," and if that much cannot be saved every day, the investment in a $300 recorder would be unprofitable.

New York City. S. F. Wilson.

Inaccuracy of Meters on Lively Lines

I am much interested in the subject of integrating devices for venturi, pitot and orifice meters and in the explanation by Allen Hazen in the issue of Sept. 5.

I found in my experiments on the flow of vapor and gases the same as Mr. Hazen found in the flow of water, that the inaccuracy of the integrating device increases as the velocity of the fluid in the pipe decreases. The reason is that at lower velocities there is a larger difference between the *square* of the average and the *average* of the respective *squares* of the quantities forming that average, owing to the fact that a given arithmetical difference in the quantity forms a larger proportion of the total number.

This inaccuracy in lively lines, however, can be eliminated when the quantity of flow is integrated electrically. To perform this integration, the mercury column actuated by the impact of the flow is made to travel along a continuous resistance forming a part of an electric circuit. This resistance is so arranged that the part cut off by the rise of the mercury column allows the current in the circuit to increase directly in proportion to the velocity of the flow affecting the rise of the column and not in proportion to the square of that velocity, which is the case with mechanically operated integrators. With this arrangement the current representing the flow is integrated instantaneously and is not affected by the possible changes in the magnitude of the flow.

Mr. Hazen draws attention to the need of some new and better apparatus for integrating flows, that would not be affected by the rapid fluctuations in velocity. It may be well to state that such an electric integrator is being used and is described in detail in *Power* in the issue of Nov. 24, 1914, page 744. J. M. Spitzglass.

Chicago, Ill.

Fan-Engine Overspeed Alarm

In connection with the fan-engine overspeed alarm described in *Power,* Aug. 22, page 288, Mr. Dickson speaks of the water in the gage evaporating so that it is necessary to add a little every day or so.

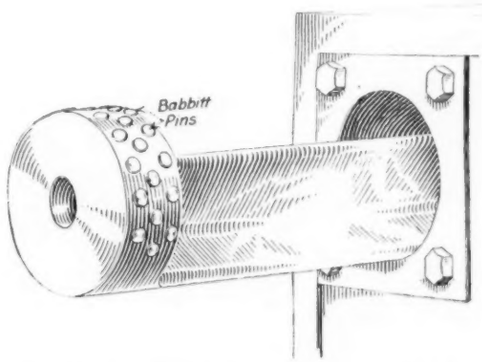
Would it not be a good idea to float a little oil on the water surfaces in the U-tube, choosing for this purpose a slow evaporating oil? W. M. Graff.

New York City.

New Valves Made Oversize

Mr. Blanchard's letter on page 363 in the issue of Sept. 5 reminded me of a Corliss engine-valve job that came under my observation some time ago.

The steam and exhaust valves and their chambers had become worn, so it was decided to rebore the chambers



OVERSIZE RELIEVED WHERE PINS ARE SHOWN

and fit new valves. The four valve chambers were accurately and smoothly trued up with a boring bar. The engineer ordered the valves turned up to a driving fit, contrary to custom, for he reasoned that Corliss valves are full size only at the ends, and at the central part which covers the port the circle is not complete, as shown in the illustration used with Mr. Blanchard's letter. By filing away a little of the upper half-circumference of each end of the valves, crescent shaped, where the babbitt pins are shown—just enough to relieve the driving fit—he secured perfect-fitting valves yet free to turn a complete revolution in the chambers.

Ordinarily Corliss valves are turned a little smaller than the bore of the chamber to give the necessary freedom and to insure against unequal expansion. But a good steam-tight fit cannot be obtained in this manner,

for the small circle cannot properly fit into a larger one, and it is not likely that the valves will wear to the seats, as some seem to think. By the driving-fit method, assuming good workmanship of course, an excellent fit can be obtained.

At first it seems unreasonable to put such a plan into practice, but as much or little may be filed off as is necessary to allow the valve to work freely and the lower or bearing part of the valve's circumference will fit exactly on its seat. CHARLES J. MASON.

Scranton, Penn.

Leak in Heater Repaired

Some time ago I installed a feed-water heater of the closed type. When put in operation, it developed a bad leak somewhere, but it was a hard matter, because of its construction, to discover which tube leaked. The face of the tube head and the face of the flange of the body came about flush, as shown in Fig. 1. It occurred to me that if I constructed some sort of a false head to prevent leakage between the expansion head and body, so that I could take off all the heads and fill the steam space of the heater with water and put it under pressure, it would be easy to find out which tube leaked. With an oxyacetylene torch the false head, or ring, was cut out of ⅜-in. boiler plate, the same diameter as the outside flange of the body, and the center was cut out the diameter of the inside of the tube head and drilled to conform with the drilling of both heads. This ring, with a gasket under it, formed a tight joint with both heads to hold the pressure to be applied to the outside of the tubes so that we could see which tube was bad.

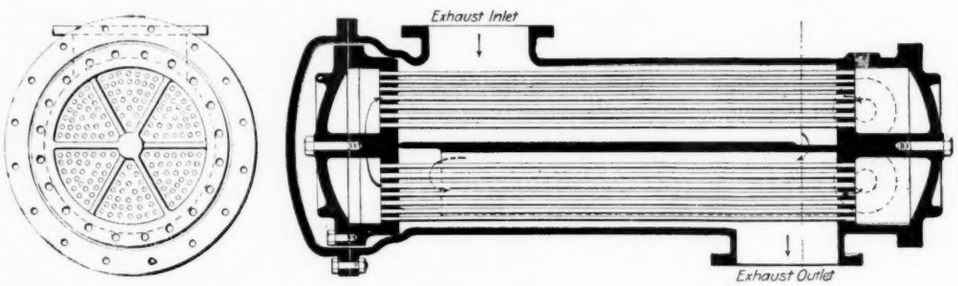


FIG. 1. TYPE OF HEATER SHOWING THE TWO FLANGES

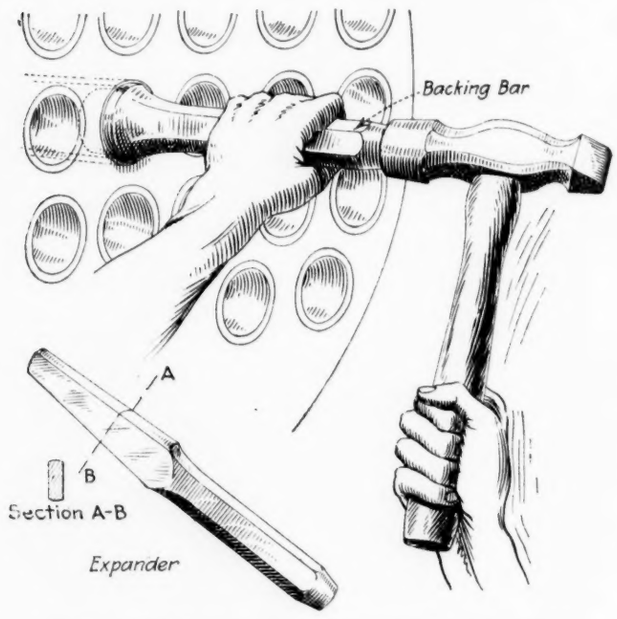


FIG. 2. TOOLS USED IN REPAIRING THE HEATER

The next question after finding the leaks was how to get the tubes out. The tool used first was a small diamond point for splitting the tubes for a distance equal to the thickness of the head (about 2 in.). After splitting and loosening tubes a little, kerosene oil was applied to cut the slight rust on the heads. I then had a small backing bar made as shown in Fig. 2, with an extension on the end to fit inside the tube and a shoulder to drive on the end of the tube with enough play so that it did not bind on either the head or the tube. While backing the first tube out, we noticed that it started to buckle up in the middle and would not leave the head at the other end. By inserting a long rod as nearly the size of the inside diameter of the tube as we could get, we were able to support it so that it would drive out without binding. The new tubes were of brass well annealed, so that they would not split.

For expanding the new tubes into the tube sheet we used a tapered tool having the same taper as the holes in the heads. The expander was turned around with a monkey wrench and tapped lightly with a hammer until the tube was seated. A. H. YOCH.

Hazleton, Penn.

Jump Spark vs. Make-and-Break

The following experience with jump-spark ignition as applied to producer-gas engines may be of interest to those who are unable to obtain satisfactory service with a make-and-break system. The equipment consisted of two 12x13-in. 80-hp. three-cylinder gas engines supplied from two 100-hp. producers. The speed is 257 r.p.m. and the compression about 90 lb. The engines are direct-connected to two 2,300-volt three-phase alternators of 62½ kw. capacity at unity power factor.

The make-and-break system was quite complicated, owing to the number of parts, and it was practically impossible to obtain reliable ignition as the wear on the various parts that made contact, the design of the plugs, the difficulty of securing and maintaining correct timing, due to the arrangement of the timing apparatus on the camshaft, were each a constant source of trouble.

After five months of experimenting and adjusting, the make-and-break system was removed and a high-tension magneto installed for each unit. The magneto generates at 9 volts and the coil, having a ratio of 1,350 to 1, steps this up to 12,000 volts, which is sufficient to produce a spark $\frac{1}{16}$ in. long under 300 lb. compression. The plugs are ⅞ in. diameter, the correct gap between the two electrodes being 5 mm. Upon the removal of the make-and-break plugs, which were 2⅞ in. long by 1⅞ in. diameter; blank flanges ⅜ in. thick were

bolted on the outside of the cylinder across the opening left by the old plugs. These were tapped to receive the 7/8-in. spark plugs. The thickness of the flanges was such that when the plugs were screwed in place, the electrodes were just flush with the inside of the flange and therefore about 2 7/8 in. from the inside wall of the cylinder.

Foundations facing the flywheel were built for the magnetos. A gear was centered on the end of the engine crankshaft, and this was meshed with a gear on the armature shaft of the magneto, the ratio of the gears being 1½ to 1, so that for an engine speed of 257 r.p.m. the armature of the magneto turns 384 r.p.m.

The current is led from the armature of the magneto, through the interrupter and then to the coil. It is here transformed, and it is then led through a high-tension secondary lead to the distributor on the magneto and finally through separate leads to each of the plugs in the three cylinders of the engine. A ground connection from the coil completes the circuit.

The timing is comparatively simple, as the apparatus for the purpose is an integral part of the unit. The magneto has a small window on the face of the distributor plate. The armature shaft is rotated until the figure 1 appears at this window. The shaft of the engine is then rotated until the piston of the No. 1 cylinder is at the top dead center of the compression stroke. The gear on the armature shaft of the magneto is then meshed with the gear on the shaft of the engine and the magneto is bolted in place. The timing adjustment is then complete unless it is desired to time any cylinder individually, in which case there is, on the distributor of the magneto, an arrangement that allows a variation of 20 deg.

There is a range of 15 deg. to advance and 15 deg. to retard the spark. This is accomplished by shifting the lever on the front of the magneto, which is attached to a pointer playing over a scale calibrated for each 5 deg.

A battery connection was provided for starting when it was supposed that the slow speed of the engine would not turn the magneto fast enough to generate the desired voltage. It was found, however, in starting by compressed air, that the engine made about 100 r.p.m. and the magneto 150 r.p.m., at which speed ignition was possible.

With the new ignition system, less gas was used, and since its installation on Mar. 8 there has been no ignition trouble. R. G. MACY.

East Norwalk, Conn.

University Extension Work

Professor Macintire's letter on "University Extension Work," page 322 in the issue of Aug. 29, is particularly interesting to me as I have been employed for the past twelve years in the educational department of the International Correspondence Schools.

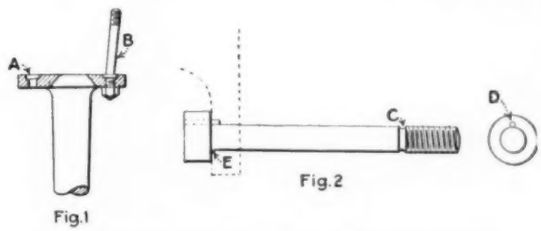
There is in the letter one statement to which I take exception, namely, that "students' papers are usually corrected by clerks who have the answers to all the questions worked out for them," etc. It is probable that the professor knows of some correspondence school where clerks correct students' papers, else he would not have said so. However, the statement is misleading, because many persons may believe that it applies to all correspondence schools. As a matter of fact it does not.

It is necessary to employ a great many people in the clerical department, but in the International Correspondence Schools not one of that class of employees has anything to do with the examination and correction of students' papers, as there is a specially trained force for this work, among them several college graduates, and the entrance examination for instructors is very rigid. Great care is taken in training the instructors, and they in turn take pains in examining the work of students.

Scranton, Penn. CHARLES J. MASON.

What Caused the Wreck?

On page 321, Aug. 29, the foregoing question is asked. Having frequently attended "inquests" on crank pin stub ends designed as shown, I have always found them rather unreliable. If the workmanship is perfect, counterbore



FAULTY DESIGN OF CONNECTING-ROD END

Fig. 1—Bad design and workmanship. Fig. 2—Improved design

and shoulders faced true, the stud should square with the face of rod, but this is not always the case. Fig. 1 shows the effect of a bad counterbore or a bad shoulder on the stud. When the nut is tightened destructive strains are set up.

I prefer a bolt made as shown in Fig. 2, with a radius at *E*, and grooved at *C*. To prevent the bolts from turning a $\frac{5}{32}$ to $\frac{5}{16}$ in. hole, depending on the size of the bolt, is drilled through the head and a piece of cold rolled steel driven through about $\frac{5}{32}$ to $\frac{5}{16}$ in.

Chrome nickel steel properly heat treated will lessen the danger of such a smashup. G. STROM.

Brooklyn, N. Y.

Illustrations and Directions for Power-Plant Equipment

We have made it a point to secure from the manufacturers of power-plant equipment such as boilers, engines, small turbines, pumps, meters and heaters, illustrations of all the apparatus we have—either outline prints or photographs showing the interior construction. We also secured whenever possible sets of directions for the care and operation of the equipment. These illustrations and the directions for operation are put in cheap frames, glass-covered and hung near the units described.

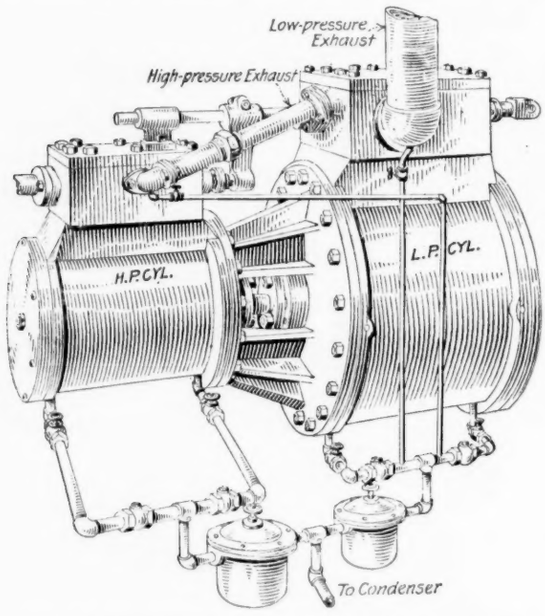
We find that everyone about the plant becomes more conversant with the construction and principle of operation of the apparatus, and the directions for operation are of considerable service, especially when new help is brought into the plant. We believe the time, effort and money expended well worth while, and it might pay others to do the same thing. We found the manufacturers ready and willing to assist in every way when they were advised of the use to be made of the illustrations.

Philadelphia, Penn. M. A. SALLER.

Piping Cylinder Drips

Referring to the inquiry of I. B. Rowland, page 396 of the issue of Sept. 12, I will state that the traps as shown connected to the cylinders always act as oil catchers. The one on the high-pressure cylinder should be discontinued. This will allow the oil it catches to find its way to the low-pressure cylinder. The drain valves can be operated by hand in starting.

The trap on the low-pressure cylinder (on account of its liability to discharge oil into the condenser, which,



MR. ROWLAND'S PIPING OF COMPOUND PUMP

if the latter is of the surface type, will have the effect of reducing the heat transfer of the tubes) should be piped to the atmosphere with a bypass around it, to be opened when starting. The slow speed of the pumps of this class makes it necessary to have a trap of some sort on the low-pressure cylinder. The water of condensation would otherwise be forced through the exhaust, and as the pressure is low, there would be a distinct knock at alternate ends of the cylinder during the operation.

I know of a pump that is equipped with a trap on the low-pressure cylinder only, that has been in operation for several years. The operator bypasses the trap for several minutes after starting. JOHN F. HURST.

Louisville, Ky.

Reduced-Pressure Economizers

Referring to Mr. Gill's letter in the issue of Sept. 5, page 359 (see also issues of Apr. 25, page 595, and May 30, page 779) regarding the desirability of operating economizers at a pressure lower than the boiler pressure by using two centrifugal boiler-feed pumps in series, the first pump discharging through the economizer to the suction of the second, thence to the boiler, I know of four installations in which this is being successfully done, the two pumps being driven in tandem by a steam turbine. Steam-turbine drive lends itself admirably to this work as automatic control is easily effected by using automatic pump governors to vary the speed of the turbines according to the demand for feed water.

An advantage that centrifugal pumps have for this work, not mentioned by Mr. Gill, is the absence of pulsation or water-hammer in the pipe system and economizer tubes.

The only precaution to be taken is to see that the pumps are so designed and the pressure so distributed that the pressure maintained in the economizer is always high enough to prevent vaporization. N. L. SNOW.

Hartford, Conn.

What Distorted the Valves?

Mr. Blanchard's answer to my query, "What Distorted the Valves?" published in the Sept. 5 issue, page 363, does not apply to my case. The boilers in the plant carry 115 lb. pressure and there is no superheat.

The superheat theory was advanced at the time, but it did not hold good. The engineer drilled a hole in the steam pipe near the engine, inserted a thermometer and read the temperature. A comparison with the steam tables showed that the steam temperature as read near the engine corresponded very closely with that as given in the steam tables at 115 lb. pressure. G. T. MICHAELS.

New York City.

Serviceable Pipe Strainer

A good serviceable strainer for a water pipe can be made by uncoupling a union or flange and inserting a disk of copper or other gauze between the two parts. The chief difficulty is that the area of the screen is somewhat limited and may soon clog up if the water is muddy.

Laurel, Md. STANLEY RADCLIFFE.

Heating-Boiler Failure

An accident to a heating boiler in one of the business blocks in Trenton, N. J., happened under unusual circumstances that may interest some readers. The boiler was of the sectional cast-iron type and furnished steam for heating a store and rooms on the upper floors of the building occupied by a business school. The accident happened about 2 a.m., blowing out the entire rear section of the boiler. The pressure was supposed to be limited to 5 lb., during the night.

The contractor who made the repairs held that low water was the cause of the failure, while the amount of water that escaped would seem to indicate that there was plenty in the system. The conclusion was that a partial vacuum had been formed in some of the upper radiators, drawing the water from the boiler.

I was unable to learn just how the different valves were set, but I can readily imagine the conditions. The supply valves to some of the radiators were evidently closed when the radiators were filled with steam and the outlet valves left open, the system being a two-pipe gravity return, the return line entering the boiler at the bottom. When the steam in the radiators condensed, a partial vacuum was formed, drawing water from the boiler, while the pressure helped to force the water up. This is a case where a good automatic air-cock was needed. The damage done was not great, but under similar conditions with higher steam pressure it, no doubt, would have been more serious. T. O. VICKERS.

Trenton, N. J.

Inquiries of General Interest

Vacuum Steam-Heating System—What is a vacuum system of heating, and why is it more effective than a gravity-return system? W. M.

In a vacuum system the return lines, or separate air pipes from the radiators, are connected with some type of condenser and air pump or receiving chamber for removing back pressure of steam and air, or air only, from the heating apparatus, thereby inducing more active circulation of the steam supplied at a given initial pressure.

Adequacy of Stack for Use of Oil Fuel—Will the chimney now used with boilers that are fired with bituminous coal be of suitable size as a stack for burning oil fuel? M. S.

For burning oil fuel the chimney capacity needs to be only about 60 per cent. of that required for the same boiler output burning bituminous coal. Hence the present chimney for the same boiler capacity is larger than necessary for fuel oil and would be adequate for about two-thirds more than the present boiler capacity.

Relative Power of Engines—With the same m.e.p., what would be the relative power developed by an engine having a cylinder 9-in. diameter by 10-in. stroke and running 300 r.p.m., and one having a cylinder 12-in. diameter by 18-in. stroke and running 110 r.p.m.? C. S.

The power in each case is directly in proportion to the m.e.p., the areas or the squares of the diameters of the cylinders, the stroke and the r.p.m. Hence the power of the 9x10-in. engine is to the power of the 12x18-in. as $(9 \times 9) \times 10 \times 300$, or 243,000, is to $(12 \times 12) \times 18 \times 110$, or 285,120, or as 1 to 1.17.

Stress on Hoop of Water Tank—What tension from the pressure of the water is brought on the hoop of a round-stayed water tank 14 ft. in diameter when the water level is 10 ft. above the level of the hoop, the hoops being spaced 12-in. centers? B. N.

Water at ordinary temperatures exerts a pressure of 0.433 lb. per sq.in. for each foot of depth, and the average pressure throughout the 12-in. layer girdled by the hoop would be $10 \times 0.433 = 4.33$ lb. per sq.in. Hence the total pressure tending to separate one-half of the layer from the other half, that is, acting across a vertical plane passed through the diameter of the layer, would be $14 \times 12 \times 12 \times 4.33 = 8{,}729.28$ lb. As the hoop at any point would be called upon to resist one-half of this total pressure, the stress would be 4,364.64 lb.

Equivalent Evaporation—With steam generated at 120 lb. boiler pressure from feed water at 190 deg. F., how many pounds of water would be equivalent to the evaporation of 34.5 lb. evaporated from and at 212 deg. F.? J. J. O.

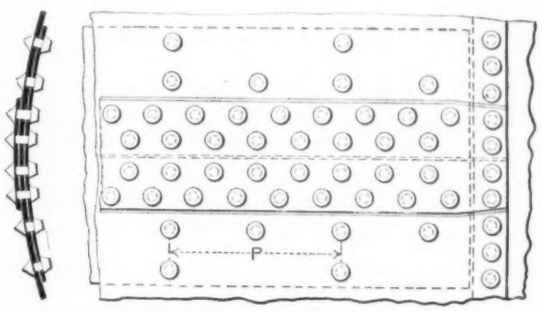
Each pound of feed water converted into steam at 120 lb. boiler pressure, or $120 + 15 = 135$ lb. absolute, would contain 1,191.6 B.t.u. above 32 deg. F., and with feed water at $190 - 32 = 158$ deg. F. above 32 deg. F. each pound of the feed water would receive $1{,}191.6 - 158 = 1{,}033.6$ B.t.u. The evaporation of 1 lb. of water from and at 212 deg. F. requires the latent heat of evaporation or 970.4 B.t.u. Hence the factor of evaporation would be $1{,}033.6 \div 970.4 = 1.0651$, and under the conditions stated the evaporation of $34.5 \div 1.0651 = 32.39$ lb. of water would be equivalent to the evaporation of 34.5 lb. of water from and at 212 deg. F.

Speed of a Generator When Operated as a Motor—Will the speed of a generator be higher or lower when operated as a motor on the same terminal voltage and load conditions as when a generator? Explain with an example. P. M.

If a direct-current generator is run as a motor at the same voltage which it generates, the speed will be somewhat lower. This is due to the voltage drop through the armature; that is, the voltage, when run as a dynamo, is exclusive of the armature drop, and when run as a motor the voltage is inclusive of the armature drop. For instance, consider that a certain machine must operate at 700 r.p.m. in order to generate 220 volts at the armature terminals, with a load of 100 amperes. If run as a motor on 220 volts and taking 100 amperes, with an armature resistance of 0.05 ohm, the drop through the armature circuit would be $100 \times 0.05 = 5$ volts. Therefore the counter e.m.f. would have to be only the difference between the applied voltage and the drop through the armature, or 215 volts, and the machine would not have to rotate as fast to generate this counter e.m.f. of 215 volts as it did when operating as a dynamo to generate 220 volts at the armature.

Efficiency of Butt Joint, Quadruple-Riveted—What would be the efficiency of a butt and double-strap joint, quadruple-riveted, in which the tensile strength of plate is 55,000 lb. per sq.in. of cross-section; thickness of plate, $\frac{17}{32}$ in.; butt straps, $\frac{1}{2}$ in.; pitch of rivets in outer row, 15 in.; diameter of rivets after driving, $\frac{15}{16}$ in.; strength of rivets in single shear, 44,000 lb. per sq.in. of cross-section; strength of rivets in double shear 88,000 lb. per sq.in. of cross-section; and crushing strength of plate, 95,000 per sq.in.? C. J.

The thickness of plate $\frac{17}{32} = 0.5313$ in.; and the diameter of driven rivets, $\frac{15}{16}$ in. $= 0.9375$ in. dia. is equivalent to 0.6903



BUTT, DOUBLE-STRAP JOINT, QUADRUPLE RIVETED

sq.in. of cross-section. For a length of joint P in the figure taken as 15 in. = pitch of rivets in the outer row, the strength of solid plate would be

(A) $15 \times 0.5313 \times 55{,}000 = 438{,}322$ lb.;

strength of plate between rivet holes in the outer row,

(B) $(15 - 0.9375)\ 0.5313 \times 55{,}000 = 410{,}927$ lb.;

shearing strength of 8 rivets in double shear plus the shearing strength of 3 rivets in single shear,

(C) $(8 \times 88{,}000 \times 0.6903) + (3 \times 44{,}006 \times 0.6903) = 577{,}090$ lb.;

strength of plate between rivet holes in the second row plus the shearing strength of 1 rivet in single shear in the outer row,

(D) $[(15 - (2 \times 0.9375))\ 0.5313 \times 55{,}000] + (44{,}000 \times 0.6903) = 413{,}905$ lb.;

strength of plate between rivet holes in the third row plus the shearing strength of 2 rivets in single shear in the second row and 1 rivet in single shear in the outer row,

(E) $[(15 - (4 \times 0.9375))\ 0.5313 \times 55{,}000] + 3(44{,}000 \times 0.6903) = 419{,}861$ lb.;

strength of plate between rivet holes in the second row plus the crushing strength of butt strap in front of 1 rivet in the outer row,

(F) $[(15 - (2 \times 0.9375))\ 0.5313 \times 55{,}000] + (0.9375 \times 0.5 \times 95{,}000) = 428{,}063$ lb.;

strength of plate between rivet holes in the third row plus the crushing strength of butt strap in front of 2 rivets in the second row and 1 rivet in the outer row,

(G) $[(15 - (4 \times 0.9375))\ 0.5313 \times 55{,}000] + 3(0.9375 \times 0.5 \times 95{,}000) = 462{,}335$ lb.;

crushing strength of plate in front of 8 rivets plus the crushing strength of butt strap in front of 3 rivets,

(H) $8(0.9375 \times 0.5313 \times 95{,}000) + 3(0.9375 \times 0.5 \times 95{,}000) = 512{,}145$ lb.;

crushing strength of plate in front of 8 rivets, plus the shearing strength in single shear of 2 rivets in the second row and 1 rivet in outer row,

(I) $8(0.9375 \times 0.5313 \times 95{,}000) + 3(44{,}000 \times 0.6903) = 469{,}670$ lb.

As the least strength is obtained per computation (B), the efficiency of the joint is $\frac{(B)}{(A)}$ or $\frac{410{,}927}{438{,}322} = 0.937$.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Central Station for Power in Steel Mills*

SYNOPSIS—A paper setting forth the growing use of purchased electric power in iron and steel rolling mills and discussions pro and con. Conditions governing its use and the establishment of correct rates enter largely.

During the last few years central-station power has become an important factor in the steel plant. Primarily the rates offered by the central station must be sufficiently low to be attractive, not necessarily lower than it can be generated at the steel plant, because there are other advantages connected with central-station power.

A large steel plant can generate its power cheaper than a small one, and for the same reason a central station having a capacity several times that of the steel plant can produce power more economically than the mill plant. This statement, of course, needs some modification, as there are many steel plants where the waste gas from the blast furnaces is used as fuel for generating the needed power. Where the surplus of such waste gases is more than sufficient for the required power, it is hard to conceive that power can be purchased cheaper than it can be produced, but there are plants requiring comparatively little power and also those which are purely rolling mills; that is, do not produce pig iron or ingots, and consequently do not have blast furnaces from which waste gases can be obtained. It is with these two classes of plants that economies and advantages are usually derived from purchased power.

There are several reasons why a large central station can generate power, and even distribute it for great distances, at a remarkably low cost. In the first place its capacity makes it desirable to install efficient generating units of the largest size, the cost per kilowatt capacity is low as compared with smaller units, and a single unit may have a capacity several times that required for the average steel plant.

Another factor is the "diversity" of the different classes of load served, resulting in a better load factor.

Besides the foregoing two reasons the central station's sole object is the manufacture of cheap power, and the entire energy of the organization is devoted to this one end.

The load factor is an important item and has a direct bearing on power cost. The load factor of a steel mill taken as a whole is fairly good, where equalizing devices are provided for reducing the momentary peak loads inherent in a mill, so that it has no detrimental effect on the central-station load factor.

Power purchased from a central station has numerous other advantages that must be considered, among them the removal of all worry and care of an isolated plant and increased reliability by reason of more specialized protective automatic switching equipment. Capital required for the construction of the power house can be used for the manufacturing plant proper, and additional power can be obtained quickly without any outlay for additions to a power house.

In making a comparison of power cost there is trouble in accurately arriving at the amount chargeable from the fact that the power department of the steel mill is so interrelated with other departments that there is difficulty in auditing the monthly expense, to charge certain items of fuel and labor to the correct account. Where steam is used for many purposes besides the production of power, the item of fuel is perhaps the most difficult of all. Too often the quantity of steam charged to power is distributed month by month for the period of a whole year on the basis of a short thermal test or else estimated from the product of kilowatt-hours times the manufacturer's guarantee of the water-rate on the generating units for full load conditions, disregarding the usual long steam lines, etc. Therefore, it is not surprising that the average steel mill can tell little about the actual kilowatt-hour cost.

It would seem that more care should be exercised in the distribution of the steam expense (fuel and labor) and that the power units should stand more nearly their just proportion of the charges with less regard to the theoretical, and also a reasonable part of the usual 15 to 20 per cent. "unaccounted-for losses" that regularly occur in the steam-distribution balance sheets.

A table of the average rate of twenty power companies furnishing power to steel mills is given for 1,000-kw. and 5,000-kw. loads at 50 per cent. load factor as follows:

	Maximum	Minimum	Average
1,000-kw. demand	1.246c.	0.700c.	0.9147c.
5,000-kw. demand	1.060c.	0.667c.	0.8464c.

The power factor when specified, varied from 60 to 90 per cent.; 8 out of a total of 11 require 80 to 90 per cent., three 60 to 75 per cent. and 11 made no reference to the power factor. The average rate of those having power factors specified were lower than those ignoring the power factor. This is because the load factor and power factor play such important parts in the cost of manufacturing and distributing electric service, that the minimum rate cannot be obtained without taking both into the calculation.

Rate schedules should be as simple as possible and avoid complicated systems of rates and discounts, and where the mill can so adjust its operations as to keep off the central-station peak, there should be a lower rate than for peak service. Some of the power companies charge only 50 per cent. of the peak-demand rates for off-peak service only.

While the difference in operating costs will not permit of uniform rates for all, they all follow the same general lines, and with different figures to fit different conditions, standard forms of rate schedules and contracts could easily be made to cover all companies. The purchaser should insist that the rate schedule be divided into demand charges and energy charges; that the demand be the average or integrated peak of 15 to 30 minutes duration; that the power factor be 80 per cent., with decrease or increase in the demand to be charged for accordingly as the power factor is above or below 80 per cent.; that the demand charges per kilowatt be in two or more steps; that the energy charges per kilowatt-hour be in two or more steps; that any excess demand occurring at other than the peak period of the power company's plant be charged at only one-half the demand charge normally applying for such excess if occurring on the power company's peak period. Long contracts made up principally of the words "whereas," "if," "and," etc., should be avoided in favor of short precise statements of what is to be furnished, how it is to be measured and what price is to be paid, leaving no doubt as to what is expected of each party.

CHARACTER OF STEEL MILL LOAD

The data secured by the committee showed that the power requirements in steel mills ranged from 1,000 to 10,000 kw. or more, a fair average probably being about 4,000 kw. The load is characterized by large peaks. Where alternating-current service is used, the power factor will vary from approximately 65 to 80 per cent., and a large generating capacity is required to provide the proper regulation.

In some contracts the power paid for is that which is delivered to the high-tension side of the transformers, being measured on the low side of the transformers and the wattmeter readings multiplied by a constant or multiplier that takes into account the transformer losses for which the purchaser pays. In others the power paid for is that which is delivered on the low side of the step-down transformers, the power company paying the losses of the first transformation, the purchaser paying for all others.

The first losses occur in the transforming station and may vary from 2 to 3 per cent., say 2.5 per cent., leaving 97.5 per cent. to be transmitted to the feeder station. The transmission losses will be from 5 to 10 per cent., say 7.5 per cent.; this will leave 90.2 per cent. of the original power delivered to the feeder station. Here it is split up. Part of it may go direct to the mills to drive the main rolls at the voltage at which it is received at the feeder station, 6,600 or 2,200 volts; some is further transformed to 440 or 220 volts for use in the induction or synchronous auxiliary alternating-current drives. This will entail another 2.5 per cent. loss, making available of that part used by these auxiliaries 87.9 per cent. Another 3 per cent. will have to be deducted for that part which is transformed from 440 to 110 volts for lighting, leaving a net available of 85.3 per cent. of the 100 per cent. set aside for lighting.

If rotaries are used, about 3 per cent. will be lost in transformers supplying the rotaries, and 5 per cent. in the rotary

*Abstract of a paper presented by the Central Station Power Committee of the Association of Iron and Steel Electrical Engineers at the tenth annual convention, Chicago, Sept. 18-22, 1916.

itself, leaving a net power delivered to the direct-current busbars of 83.1 per cent. of the original, for use by the rotaries.

If motor-generator sets are used, the losses of transformation will be about 12 per cent., leaving a net power delivered to the direct-current busbars of 79.4 per cent. of the original power for the motor-generator sets. A summary of the losses is given in the table.

LOSSES INCURRED IN DISTRIBUTING CENTRAL-STATION POWER FROM RECEIVING STATION TO PLANT FEEDER STATION BUSBARS

	Original Power Delivered by Transmission Line, Per Cent.	Transformer Losses from Line to 6,600 or 2,200 V., Per Cent.	Transmission Losses from H. T. Transformer to Feeder Station, Per Cent.	Transformer Losses 6,600 or 2,200 V. to 440 V., Per Cent	Transformer Losses 440 V. to 110 V., Per Cent.	Rotary Losses Per Cent.	M. G. Set Losses, Per Cent.	Net Power Delivered to Feeder Station Busbars, Per Cent.	Increase in Initial Cost of Power, Per Cent.
Mill drives..	100	2.5	7.5	...	...	...	...	90.2	11.9
A.-c. auxiliaries.	100	2.5	7.5	2.5	...	...	...	87.9	13.8
Lighting	100	2.5	7.5	2.5	3	...	...	85.2	17.4
Rotary converters.....	100	2.5	7.5	2.5	...	5	...	83.1	20.3
M. G. sets....	100	2.5	7.5	...	...	...	12	79.4	26

DISCUSSION

Noble Jones: It is true that purchased power is being used more extensively every day, doubtless due in a great measure to the activeness of the power companies' representatives and the apparent inactiveness of steel-plant engineers. The power company is ready with figures more or less confusing, giving costs to the prospective consumer. In many steel-mill power plants it is difficult to properly segregate costs and the plant engineer is at a loss to know accurately the cost of generated current. It would be interesting if figures had been given regarding the cost of generating current, so that a comparison could be made. I believe that several plants are generating current at a less cost than it could be bought for and that there are several more plants which, by the addition of a few refinements, would effect economies that would place them in the same class. To get the low rate it is necessary to furnish an ideal load; that is, a good power factor and load factor. Then why not do this for the private plant and get further economies? Generating current at the plant means a saving of some line loss and often transformer and frequency-changer loss. In most cases the continuity of service is better in the private plant, and this may be of inestimable value.

Much has been said of the flattening of load curves, but by going back to the boiler room it will be found that the electric-power plant helps to give a more uniform and economical load there, when operating together with the necessary direct-steam driven apparatus, which in many plants would entail considerable expense to dispense with.

In some cases a few of the attendants in the steel-mill power plant may be done away with if power is purchased, but frequently these same men look after other power equipment such as pumps, compressors, etc. Therefore, they should be considered in comparison with any men required to care for converters, etc., if power is purchased.

F. D. Egan: The adoption of central-station power will result only from the economical advantages of such power. Where steel plants convert from iron to finished product, the use of central-station power is unlikely. However, in small plants converting from billets, slabs, etc., to finished product, a different set of conditions may make central power desirable. Even here, when the problem is carefully analyzed, some cases are found for which central power will not be advantageous. As an example, take a plant that is using steam-driven blooming mills and finishing mills. Here the cost of electrical power should not be considered as a separate item, for it may add a steadying load to the boilers and so increase the over-all efficiency of the entire plant. The ultimate problem therefore resolves itself to that of plant efficiency.

Where mills are electrically driven and all auxiliaries are the same, without doubt the total load can be purchased more cheaply from a central station than it can be produced in the steel plant. However, this condition is due to the economies gained from the changed drives on the mills and not to the advantages of central power.

In any steel plant that is arranged to allow for expansion, the engineer should carefully consider the power end. Using purchased power at 25 cycles would obviate the necessity of later changing the various drives or installing a frequency changer. During the past year the natural gas shortage and the erection of byproduct coke ovens has made this consideration important. The use of coke oven or producer gas in the open hearth results in high stack temperatures and requires the installation of waste-heat boilers for good economy. Also, if during the plant's growth a blast furnace is erected, the resulting waste heat added to that of the waste-heat boilers would put the steel plant in a position to sell rather than purchase power.

Central-station peaks come, on the average, at 7 o'clock in the morning, 12 o'clock noon, and 5 to 6:30 in the evening. The shops and a great number of the machines for finishing the product slow up at about, say, 5:30 o'clock in the evening. At that time the large power plant in the steel plant could help out the central station, and by drawing on it earlier in the day the load curves of the two plants could be flattened materially.

The average steel-mill load is variable and characterized by large peaks. The inefficiency of such a load would favor centralization. However, properly balanced steel-plant loads can be obtained, and by proper balancing with synchronous machinery, a unity power factor rather than one of 80 per cent. is practical.

SMALL FLUCTUATION IN LOAD

During an average 24-hr. run the total load curve in our Midland plant showed a continuous fluctuation of not over 250 kw. and the maximum and minimum outputs were respectively 3,200 and 1,800 kw., the average load throughout the day being fairly constant at 2,300 kw., 97 per cent. power factor.

In regard to steam distribution the practice of the Steel Corporation and a number of other concerns is to provide each boiler plant with venturi meters on the boiler-feed water, individual steam-flow meters on the boilers, and on all operations of a continuous type, representing blowing engines, pumping stations, etc., continuous steam-flow curves are taken.

It is true there is an unaccounted-for loss of 20 per cent., caused by blowing off and washing out boilers, but as the distribution of steam is made on the basis of the curves, all stand-by losses are proportioned to this demand, and the losses are properly taken care of.

The committee referred to the cheap cost of power made from blast-furnace gas. The boiler house is not getting the gas for nothing. The furnace is given credit for the proper weight of coal at its cost in the district.

Paul H. Stambaugh: Exception may be taken to the statement, "Where the surplus of such waste gas is more than sufficient for the required power, it is hard to conceive that purchased power can be obtained at a lower rate than that at which it can be produced." The issue in this case is not one primarily of advantageously producing power, but rather advantageously disposing of gases. Steel mills having byproduct or waste gas of any kind have no reason to expect that the gas supply will be at their disposal for power purposes in accord with the cycle of demands for power—the result being that all the gas cannot be utilized to best advantage. Would it not be well worth while for those confronting this problem, both steel-mill men and central-station men, to give some thought to a scheme by which every cubic foot of waste gas could be utilized at maximum efficiency? Such a result might be accomplished by using the gas as fuel for a central-station power house, the central station purchasing the gas from the steel mills and the mills in turn purchasing their electric energy from the central station. One result of such an arrangement would be a saving in coal; another would be combined diversity of gas supply and power supply.

Power companies in general realize that loads such as furnished by steel mills can be handled advantageously from their service lines, and as a result considerable effort has been and is being made toward the taking on of such loads. Ultimately this question must present itself: How far can the central station go with low price inducement and still maintain power service more dependable than other sources of supply? In a steel mill having the power on and plenty of it is of primary importance, cost being secondary. This is true regardless of the source of supply.

S. C. Coey: A number of plants are installing meters and getting their steam and power costs more accurately than in the past. This is the only way in which to determine whether to buy or generate current.

In some localities the steel plant may be developing a great deal more steam than the central station, and with efficient boilers the cost of steam may well be lower than at the central-station plant, irrespective of the blast-furnace gases or other waste heat. The cost of power in the larger steel plants is now as accurately determined as in most of the central-station plants, but when it comes to setting aside cer-

tain amounts for depreciation, obsolescence, interest on investment and regular fixed charges, I am not so sure that the steel plants have been as liberal in their estimates. Years ago, when blast-furnace gas was blown to the winds and then later put under boilers, I do not believe much record was kept of the cost of that gas as a charge against the cost of generating power, but that was some time ago. Owing to constant improvements, the necessity for large reserve capacity in blast-furnace gas engines has been eliminated. That central-station power is more reliable than a private plant is an open question. It is advisable to make sure that the plant from which the power is being purchased is large and that its source of energy is reliable, and further, that the feeder connections are dependable.

The whole subject boils itself down to the fact that any plant having waste energy of any character whatsoever, whether it is waste heat from an openhearth furnace, blast-furnace gas, byproduct coke-oven gas or what not, must consider seriously the use of every available B.t.u. of that energy before purchasing power.

William O. Oschmann: In comparing the cost of purchased and generated power, it might be mentioned that the power company makes its profit from the sale of the energy that it generates, while the steel company makes its profit from steel, not from power. Therefore it is necessary in the case of the power company to add a profit to the cost of generating power. Also, in the central-station power the salary of the president, superintendents, office clerks, etc., must be added, while in the steel works, as a rule, the salary of the superintendents and other expenses are a small percentage of the charge to power generation and are charged largely to the product of the mill.

Robert W. Drake: In the discussion one of the speakers stated that in using waste heat the big supply of gas and the peak-power demands seldom coincided, especially in plants that do not operate on the 24-hr. basis. It is frequently necessary to install an auxiliary coal-fired plant, which makes a duplication in investment and runs the fixed charges to a high figure. It is not often that a waste-heat plant can be installed for anything approaching the cost of a standard coal generating station, even though the boilers are placed in the gas discharge from the furnace. The high investment reflects such a large overhead charge, especially in 10- or 12-hr.-day operation, that such a waste-heat installation may show very little saving over a coal plant of the same size, and brings the operating cost to a point where the central station can compete on favorable terms.

PROVISION FOR PLANT EXTENSION

There is one thing that all must fight against, whether big or little, and that is, when the manufacturer puts in a good, economical, well-planned plant to start with, and then as need for extensions come, the constant tendency of the directors is to make piecemeal extensions due to space or financial considerations at the time. This means a plant of small units, ill-fitted to give the best efficiency, and consequently an increase in the cost of power. The central station is more careful in these respects and is working toward larger and larger units all the time.

There is one good thing about introducing central-station power into a plant if it is a comparatively small percentage of the total power used, and that is, when the costs are compared, there is often so small a margin that the manufacturer's engineering force try to increase it and therefore raise the efficiency of the home generating station to quite an extent.

Brent Wiley: Some plants grow so rapidly that it is hard to decide on the details that will give the most economical station, and provide for the ultimate enlargement of the plant, within a comparatively short time. This is a feature of the central-station proposition that has appealed to a great many of the steel plants; namely, that they can add to their load in an economical way. Another is that as their load increases they are working toward a betterment that can be definitely realized as they go along.

With either kind of service it is necessary to definitely establish the conditions under which the mill is going to use the power, and until those facts are established, neither the central station nor the steel company can give the matter the best consideration, and that brings out another point—the value of records.

It is difficult to predict plant conditions, to know what extensions are going to be made and how rapidly they are going to be carried out on the change in plant conditions.

Some of the larger companies recently have been acting on the plan of laying out a broad campaign of improvement and then working to that end. This is one of the most important considerations in steel-plant improvements as viewed at present.

T. E. Tynes: One of the most prominent and encouraging features brought out in connection with this paper and the discussions is the fact that the central-station engineers and the steel-plant engineers are getting together on the question of power. The steel-plant people want as low a rate as they can get, and the central station engineers want to give that rate, consistent with the characteristics of the load which is demanded from them. Two of the most important elements contributing to low rates are load factor and power factor, and if the central stations can be guaranteed a high load factor and a high power factor, they will give a much better rate than if those factors are low. To meet these conditions it is necessary to utilize the heat energy going to waste around the plant to take the peaks, giving the central station practically a constant load.

The Use of Steel Conductors for Transmission Lines*

By H. B. Dwight

Although the tests to determine the electrical properties of steel wires and cables are incomplete, they nevertheless show some attractive possibilities from both commercial and engineering points of view for the use of steel instead of copper for certain classes of work. Already small-sized steel conductors have been used with success in America, and this practice may be extended by a knowledge of the characteristics of large steel cable.

The resistance of an iron or steel conductor is considerably greater for alternating current than for direct current. This is partly due to the skin effect—that is, the crowding of the alternating current to the outside part of the conductor—and by hysteresis or iron losses caused by the alternating magnetic flux in the steel.

Although high-grade steel wire proved to be the best conductor for direct current, on account of its higher permeability to magnetism it has a higher resistance to alternating current than a low-grade, less-expensive conductor. Thus the cheaper grade was found to be more suitable for alternating-current work. This conclusion is also stated in a recent Bulletin, No. 252, of the Bureau of Standards, Washington, D. C. The Bureau tests show that at commercial frequencies the increase of resistance is approximately proportional to the frequency. It is of interest to note that increasing the number of wires in a cable decreases the reactance, while increasing the size of the wires increases the reactance.

Another point brought out by the test is that a large part of the magnetization is caused by the spiraling of the wires in the cable. If the spiraling of the different groups of wires is properly reversed, the increase of effective resistance can be reduced as much as one-half. Thus, if the spiraling of one layer of wire is clockwise, the next should be counterclockwise.

The effective resistance and reactance of a steel conductor increases as the current increases. This, however, only continues to a certain point where the effective resistance begins to decrease again. In both cases, especially in large cables, the decrease is very slow and the resistance is maintained approximately at its maximum value for large value of current. This property should prove useful in transmission-line work, for the conductor will have a low impedance to the normal load current, but will have about twice as much impedance to the current flowing in case of a short-circuit. The impedance will also be large in high-frequency surges, caused by switching or lightning. It may prove more economical in certain cases to protect a line against short-circuits and surges by using steel conductors than by installing current-limiting reactors or by increasing the reactance of the transformers.

This property may also be used in the case of feeders of direct-current interurban railways. If the feeder be a steel cable, it will have low resistance to direct current but high resistance to alternating current. It will therefore tend to dampen out the suddenness of short-circuits and lightning surges, which cause synchronous machines to flash over.

If the feeders are made of steel, and especially if the stranding be coarse, the required protection will be still more complete. Steel conductors would probably be economical only where it is allowable to use bare cable, as the increased amount of insulating covering required for large-sized steel cables, compared with copper ones of the same conductivity, would greatly increase the cost of the former.

The higher conductivity of steel for direct current than for alternating current makes the use of bare-steel cables for

*Abstract of a paper presented at the tenth annual convention of the Association of Iron and Steel Electrical Engineers in joint session with the American Institute of Electrical Engineers, Chicago, Ill., Sept. 18-22, 1916.

direct-current feeders more economical than for alternating-current. A steel cable has about eight times as much resistance to direct current as a copper cable of the same size and seven times as much resistance as a copper cable of the same weight, since copper is more dense than steel. Galvanized steel cable usually costs less than one-seventh as much per pound as copper cables and so should be more economical, other things being equal.

A large 60-cycle power system in the State of Washington makes use of a considerable quantity of No. 8 iron wire for short tap-offs and lightly loaded branch lines on 6,600-volt circuits, without serious trouble resulting from voltage drop. The iron wire is far cheaper than No. 6 copper. One line built by the company is an example showing that it may be profitable to supply a surprisingly small load at a distance of several miles. This line is 10 mi. long and was originally built with No. 8 copper-clad steel to supply a 50-hp. load at 6,600 volts. The line afterward carried 110 hp. for some time and was later changed to No. 6 copper in order to have a capacity for a still greater load.

An example from Minnesota shows the use of a somewhat larger steel conductor. This line operates at 40,000 volts 60 cycles and is 20-mi. long. No. 4 galvanized-steel cable made of three wires is used. The load is about 300 kv.-a.

An example of an 11,000-volt line designed for 75 kv.-a., the smallest size of copper conductor that can be used is No. 6 B. & S. and would cost $2,600. A 25,000-circ.-mil steel conductor can be used and will cost only $220. The copper conductor in this case has a capacity of 750 kv.-a., but on account of mechanical strength a smaller conductor cannot be used.

Besides being cheaper than a copper cable for small branch lines, the steel cable has the advantage of being mechanically stronger and less liable to be burned through by arcs. The steel is therefore of greater reliability at times of wind storms and at times of electrical breakdowns or trouble. Steel cables are subject to the disadvantage that their useful life is shorter than that of copper cables, especially near the seashore, where galvanized steel is more quickly oxidized.

The price per pound of copper cable may be assumed as being ten times that of galvanized-steel cable. This ratio is a usual one, being approximately true for times when prices of metals are low as well as times when prices are high. From the data available it seems probable, considering a heavy transmission line complete with towers and insulators where an extra weight of steel conductor would be troublesome, the cost will be approximately the same for the two materials. However, there are many cases where extra strength and size of steel cables are advantageous, and so at present the chief attention should be given to the classes of work where steel can show other advantages than merely low cost on a basis of carrying capacity for alternating-current power.

On very high-voltage transmission lines where the corona limits determine the size of conductors, the steel conductors have an opening, for use on branch lines supplying a few thousand kv.-a. on net works of 100,000 volts and higher.

In conclusion it has been shown that large steel cable, if properly manufactured, can be used for carrying alternating current. It appears that the chief opportunity for the use of steel conductors is on branch lines where the size of copper required merely for the electrical loads would be too small to use. However, in all cases steel conductors will be nearly as cheap as copper ones, if not cheaper, and the use of steel will always increase the reliability of the transmission system.

Water Power in Alaska

Desirous of obtaining detailed authoritative information as to the location of the best water-power sites in southeastern Alaska, as well as a report as to the development of the resources in this section of the country, George H. Canfield, one of the field experts of the United States Geological Survey, was recently instructed to visit this section and to report to the Department of the Interior as to his findings. Mr. Canfield's report, a digest of which follows, was recently submitted and contains much information of interest to water-power users.

The streams of Alaska, states the report, have been important factors in the industrial growth of the territory. The success in placer mining in northern and central Alaska has depended primarily on the water available for hydraulicking and dredging, and in southeastern Alaska water power has long been used by mines, canneries, sawmills and other industries, although until recently most of the plants have been small.

Since 1906 the United States Geological Survey has made systematic studies of the water resources of Alaska. Investigations with special reference to placer mining have been made in Seward Peninsula and the Yukon-Tanana region, and reconnaissance surveys for water powers have been made about Prince William Sound, Copper River, Kenai Peninsula and in other parts of southeastern Alaska.

In the summer of 1914 Leonard Lundgren, central district engineer of the Forest Service, made a reconnaissance of water-power sites in southeastern Alaska to determine the possibility of establishing the pulp industry in the Tongass National Forest, which covers a large part of this territory. In connection with this reconnaissance a census of water powers was taken and recently revised to date. This table, showing the developed water powers in Southeastern Alaska in horsepower, follows:

Ketchikan Region:	
Citizens Light, Power and Water Co.	2,000
New England Fish Co.	2,200
Miscellaneous plants	1,000
	5,200
Wrangell Region	0
Sitka Region:	
Sitka Wharf and Power Co.	350
Chichagof Mining Co.	500
Miscellaneous plants	150
	1,000
Juneau Region:	
Douglas Island Plant	4,000
Sheep Creek Plant	4,100
Nugget Creek Plant	5,700
Salmon Creek Plants (Nos. 1 and 2)	8,000
Annex Creek Plant	5,000
Alaska Electric Light and Power Co.	1,000
Miscellaneous plants	1,000
Total	28,800
Skagway Region	100
Total	35,100

During the last few years some large water-power plants have been installed near Juneau to supply power for mining, and attention has been called to the feasibility of improving other power sites in that region and elsewhere in southeastern Alaska, to meet the increasing demand for power to be used in mining, lumbering and fisheries, and the probable future demand for its use in the manufacture of wood pulp and electrochemical products. The streams on which it is possible to develop power and the ways or other water bodies into which these streams discharge are listed as follows:

Mainland—Porcupine River, near Porcupine; Endicott River, west coast of Lynn Canal; Cowie and Davis Creeks, Berners Bay; Lemon Creek near Juneau; Carlson Creek, Taku Inlet; Turner Lake outlet, Taku Inlet; Speel River, Speel River project, Port Snettisham; Grindstone Creek, north shore of Stephens Passage; Rhein Creek, north shore of Stephens Passage; Long Lake outlet, Speel River project, Port Snettisham; Crater Lake outlet, Speel River project, Port Snettisham; Tease Lake outlet, Speel River project, Port Snettisham; Sweetheart Falls Creek, south arm of Port Snettisham; Port Houghton, Stephens Passage; Farragut Bay, Frederick Sound; Mill Creek, near Wrangell; Bradfield Canal, upper end of Cleveland Peninsula; Smugglers Cove, southeast shore of Cleveland Peninsula; Helm Bay, southeast shore of Cleveland Peninsula; Shelockham Lake outlet, Bailey Bay; Chickamin River, east shore of Behm Canal; Rudyerd Bay, east shore of Behm Canal.

Baranof Island—Port Conclusion, southeast coast; Patterson Bay, east coast; Red Bluff Bay, east coast; Cascade Bay, east coast; Baranof Bay outlet, Warm Spring Bay, east coast; Kasnyku Bay, east coast; Green Lake outlet, Silver Bay, west coast; Necker Bay, west coast; Deep Bay, west coast.

Chichagof Island—Slocum Arm, west coast; Sulois Bay, Peril Strait; Khaz Bay, west coast; Freshwater Bay, east coast; Sitkoh Bay, southeast coast; Basket Bay, southeast coast.

Admiralty Island—Kootznahoo Inlet, west coast; Hood Bay, west coast.

Kosciusko Island—Davidson Inlet.

Prince of Wales Island—Karta River, Karta Bay; Whale Passage, behind Thorne Island, northeast coast; Myrtle Lake outlet, near Niblack post office; Reynolds Creek, near Coppermount.

Revillagigedo Island—Orchard Lake outlet, at Shrimp Bay; Beaver Falls, George Inlet; White River, George Inlet; Fish Creek, Thorne Arm; Gotchin Creek, Thorne Arm; Ketchikan Creek, at Ketchikan.

Annette Island—Tamgas Harbor.

Lack of definite information in regard to the quantity of water available and other physical factors that determine the feasibility of a power site has been one of the principal impediments to development. For this reason a systematic investigation, designed to determine the location and the feasibility of water-power sites in southeastern Alaska was begun by the Geological Survey in the spring of 1915.

The practicability of a water-power site depends on the quantity of water available, the fall and the possibility of storing water. Information in regard to fall and storage can be obtained by surveys at any time, but the volume and distribution of flow can be determined only by observations extending over several years, as future flow must be predicted by that of the past. In beginning the investigations, therefore, the collection of stream-flow data was given precedence and constituted the principal work of the year. Some general information, however, has been obtained, and in the fall of 1915 a few rainfall stations were established at higher

elevations to supplement observations at mean sea level by the United States Weather Bureau. As a result of these investigations, records of flow are now available for nine gaging stations, as follows: Fish Creek, near sea level, Revillagigedo Island; Ketchikan Creek at Ketchikan; Karta River, at Karta Bay, Prince of Wales Island; Orchard Lake outlet, at Shrimm Bay, Revillagigedo Island; Shelockham Lake outlet at Bailey Bay; Mill Creek on mainland near Wrangell; Sweetheart Falls Creek near Snettisham; Baranof Lake outlet at Warm Spring Bay, Baranof Island; Green Lake outlet at Silver Bay, near Sitka.

The available power sites in each area were carefully considered and gaging stations established at those that apparently afforded the greatest opportunity for development. The records have been collected in accordance with the standard methods used elsewhere in the United States by the Geological Survey. Owing to the inaccessibility of the stations, water-stage recorders were used at all the stations except that on Ketchikan Creek, and cables have been installed from which discharge measurements are made. Special arrangements were made for observations through the winter to obtain a record of the low-water flow that occurs at that season.

The data collected at the gaging stations mentioned in the Canfield report are on file at the Geological Survey in Washington, D. C., and copies of any or all of these station records may be obtained by addressing the Survey. Each of the records contains detailed information as to the location, drainage area, available records, gage, discharge measurements, channel and control, the extremes of discharge, the winter flow and the accuracy of the measurements.

NEW PUBLICATIONS

STEAM POWER. By C. F. Hirshfeld, formerly professor of power engineering, Sibley College, Cornell University, and T. C. Ulbricht, formerly an instructor in Cornell University. Published by John Wiley & Sons, New York and London. First edition. Cloth; 7½x5 in.; 420 pages; indexed; illustrated by 228 charts, diagrams and cuts. Price, $2.

The purpose of this book, as stated by the authors, is to present such information to engineers whose work does not require knowledge of the more complicated thermodynamic principles as will give them a correct viewpoint with regard to the use of heat in the power plant, even though it does not enter deeply into the theoretical considerations leading up to that viewpoint; to supply the tools required for the solution of power-plant problems of the common sort. Mathematical treatment has largely been eliminated, and anyone familiar with elementary algebra should be able to understand readily such equations as are found in this book. Brief explanations of physical and chemical concepts are given in every case in which the text requires their use, so that those who have not studied these subjects should have little difficulty in reading this part of the text understandingly.

The first natural division of the table of contents comprises (1) Physical Conceptions and Units, (2) The Heat-Power Plant, (3) Steam, (4) The Ideal Steam Engine, (5) and (6) Entropy Diagrams and Temperature Entropy Diagrams of Steam Cycles. Then comes (7) The Real Steam Engine, (8) The Indicator Diagrams and Derived Values, (9) Compounding, (10) The D Slide Valve, (11) Corliss and Other High-Efficiency Engines, (12) Regulation, (13) The Steam Turbine, (14) Condensers and Related Apparatus. Combustion and Fuels (Chapters 15 and 16) deal with the theoretical aspect of these subjects, giving definitions and the heat values and composition of various combustibles, followed by Steam Boilers (17), Recovery of Waste Heat (18), and Auxiliaries (19), closing with a few pages of steam tables.

As to be expected, the treatment throughout is pedagogic and requires study, and each chapter closes with an illustrative problem making an application of the subject matter preceding. This is one of the "Wiley Technical Series" for vocational and industrial schools and is well adapted to the purpose intended.

PERSONAL REMINISCENCES OF THE LATE JAMES MAPES DODGE. By Charles Piez. The Link-Belt Co., Philadelphia, Penn. Size, 5x8 in.; 23 pages; illustrated with numerous halftones, including a full page frontispiece of Mr. Dodge.

The story of the struggles, failures and final success of this pioneer in the introduction of coal conveying and storage machinery, and later of the silent chain drive, is interestingly told by one who was associated with him for 25 years. Mr. Dodge, while president of the American Society of Mechanical Engineers, became deeply interested in the factory organization work of Mr. Taylor and no doubt influenced the latter in no small degree to recognize that there was a human as well as a mechanical element to be taken into consideration. The booklet is for free distribution on request.

MASSACHUSETTS BOILER RULES

The rules formulated by the Massachusetts Board of Boiler Rules have been reprinted in a pocket-size volume 4¼x6¾ in., containing 114 pages, with cardboard cover, making a much more convenient book for the inspectors, for whose particular use it is designed, to carry. This printing embodies the latest amendments, which will be found on pages 36 and 37 of "Power" for July 4.

THE FLOW OF WATER IN WOOD-STAVE PIPE

"The Flow of Water in Wood-Stave Pipe" is the title of a new professional paper of the United States Department of Agriculture, Department Bulletin No. 376, by Fred C. Scobey, irrigation engineer. The bulletin is based upon the results obtained through a large number of experiments on the flow of water in wood-stave pipes ranging from 8 in. to 13½ ft. in diameter. The work also included the collection and analysis of available records of all previous experiments of a similar character. From the results of all experiments made, there has been deduced a new set of formulas for the flow of water in stave pipes. The bulletin is highly technical in character, and its distribution is limited to engineers and others concerned with the use of wood pipe for conveying water for irrigation, power, municipal, mining and similar purposes. Application for the bulletin should be addressed to the United States Department of Agriculture, Washington, D. C.

PERSONALS

George E. Clifford has been appointed chief engineer of the Philadelphia Bureau of Charities.

N. B. Stearns has been appointed power engineer of the Union Light and Power Co., Franklin, Mass.

Austin D. Keables has accepted the position of mechanical engineer for the Slatersville Finishing Co., Slatersville, R. I.

Frank E. Leahy has been promoted to the position of steam and hydraulic engineer of the National Tube Co., Pittsburgh, Penn.

Charles J. Gadd has been appointed chief engineer of the Lebanon (Penn.) plant of the American Iron and Steel Manufacturing Co.

P. J. Freeman, formerly professor of applied mechanics at Kansas State College, is now engineer of tests at the Pittsburgh Testing Laboratory.

Charles Gardner, formerly with the Miller Saw Trimmer Co., of Pittsburgh, is now chief engineer of the Independent Brewing Co., of Pittsburgh.

Henry A. Stringfellow, consulting engineer of Rochester, N. Y., has been made consulting engineer for the Sedgwick Machine Works, of New York.

A. G. Williams, assistant master mechanic of the Western Pennsylvania lines, has been appointed assistant engineer of motive power, succeeding L. B. Jones.

C. W. Hays, formerly with Boyts, Porter & Co., Connellsville, Penn., is now associated with the Ross Mechanical Supply Co., in charge of the pump department.

E. H. Beam, of Knoxville, Tenn., has been appointed department manager of the Niagara Light, Heat and Power Co., at North Tonawanda, N. Y., to succeed C. G. Murdock.

C. B. Carver has resigned as junior engineer for the New York Conservation Commission to enter the engineering department of the New York Central R.R. in New York City.

Fred G. Lundgren, who has been with the American Car and Foundry Co., at Terre Haute, Ind., has been transferred to the company's plant at Milton, Penn., as master mechanic.

Frederick W. Starr, until recently publicity manager of the Pope Manufacturing Co., Westfield, Mass., has joined the force of the Toledo Scale Co., with offices at Hartford, Conn.

H. A. Hurckes, for years chief engineer of the Illinois Vinegar Manufacturing Co., of Chicago, has been appointed to represent the Thomas P. Ford Co., of New York, in the Middle West.

E. T. Foote has been transferred from the New York office of the Cutler-Hammer Manufacturing Co., to take charge of the company's Boston office, located in the Columbian Life Building.

William H. Boehm was recently made vice-president of the Fidelity and Casualty Co. of New York. He will continue to superintend the departments of steam-boiler and flywheel insurance.

E. H. Bolton, formerly sales engineer with the Colles Heater and Specialty Co., of Chicago, has been appointed to represent the Thomas P. Ford Co., of New York, in the Middle West.

Arthur W. MacNabb, formerly in the engineering department and inspection division of the Fidelity and Casualty Insurance Co., is now connected with the National Meter Co., Brooklyn, N. Y.

Henry J. Hanzlik has resigned as mechanical engineer of the De Laval Steam Turbine Co., Trenton, N. J., and accepted the position of consulting engineer of the Kerr Turbine Co., Wellsville, N. Y.

T. H. Farmer, formerly chief engineer of the Kentucky Utilities Co., has been transferred to Pennington Gap, Va., as chief engineer of the Electric Transmission Co., a branch of the former company.

Lewis F. Moody, for many years connected with the faculty of Rensselaer Polytechnic Institute, has resigned as professor of hydraulic engineering and will act as consulting engineer for the I. P. Morris Co., Philadelphia, Penn.

Thomas H. Platt, of the Dearborn Chemical Co., who was president of the Connecticut State Supplymen's Association, has been elected a member of the board of directors of the New England Association of Commercial Engineers.

Joseph Esherick has resigned as manager of the valve and specialty department of the Yarnall-Waring Co., of Philadelphia, to become the Philadelphia representative of the D. Connelly Boiler Co., National Steam Pump Co. and the Foxboro Co.

James Markham, well known in N. A. S. E. circles and a delegate to many of the conventions of that association, has resigned as chief engineer for Swift & Co. at Lowell, Mass., to accept a position as lubricating engineer with the Gulf Refining Co.

Arthur H. Halloran, managing editor of the "Journal of Electricity, Power and Gas," of San Francisco, has been appointed Pacific Coast representative of the Society for Electrical Development, Inc., with headquarters in the Crossley Building, San Francisco.

John F. Vaughan has opened an office at 185 Devonshire St., Boston, for the practice of consulting engineer. He has been retained by the Boston banking house of Estabrook & Co. in connection with the redevelopment of a 20,000-kw. hydro-electric plant at Sault St. Marie, Ont.

J. F. Gould secretary of the local committee, in appreciation of his good work in connection with the convention of the N. A. S. E. at Minneapolis, was presented a diamond and pearl scarfpin by the National Exhibitors' Association, the speech being made by Secretary J. William Petersen.

W. C. Callaghan, formerly superintendent of the Helena Light and Railway Co., at Helena, Mont., has resigned to become general manager for the J. G. White Management Corporation, which has taken over the management of the operating department of the Shore Line Electric Railway, with offices at Norwich, Conn.

H. Schreck has been appointed chief engineer of the Diesel engine department of the Fulton Iron Works, of St. Louis. His former position with the company was that of assistant chief engineer. Mr. Schreck has had a wide European experience in the manufacture and development of Diesel engines of both the marine and stationary types.

E. M. Anderson, who has been successively engineer with the Charleston (S. C.) Electric Light Co., the Westinghouse Co., superintendent of the Spartanburg Gas and Electric Light Co., superintendent of the municipal plant at Union, S. C., and superintendent of the Abbeville Utilities property, has been elected president of the Tri-State Water and Light Association of Georgia and North and South Carolina.

Dr. C. O. Mailloux, consulting electrical engineer, of New York City, sailed for France on Aug. 26 to study electrical conditions in the French Republic, as a member of the American Industrial Commission. Dr. Mailloux is a past president of the United States national committee of the International Electrotechnical Commission and of the American Institute of Electrical Engineers, and was one of the first to take up electrical engineering as a profession in this country.

Dr. William McClellan, consulting engineer of New York City, and former chief engineer for the New York Public Service Commission for the Second District, has been appointed dean of the Wharton School of Finance and Commerce of the University of Pennsylvania. For a time Dr. McClellan was engineer in charge of construction for the Philadelphia Rapid Transit Co. Later he became supervising engineer for Westinghouse Church Kerr & Co. and more recently joincd the engineering firm of H. T. Campion, of Philadelphia. He is a member of all the leading American engineering societies.

ENGINEERING AFFAIRS

The American Association of Refrigeration will hold its sixth annual meeting at the Congress Hotel, Chicago, Oct. 11-13.

The New England Section of the National Electric Light Association will hold its annual convention in Pittsfield, Mass., Oct. 17-20.

The Empire State Gas and Electrical Association will hold its annual convention in the United Engineering Societies Building, New York, Oct. 5-6.

The American Institute of Electrical Engineers will hold its 325th meeting in Philadelphia on Oct. 13, at the University of Pennsylvania. The subject of the meeting will be "Electrical Supply for Large Single-Phase Load."

The American Electrochemical Society held its thirtieth general meeting in New York City, Sept. 27-30, with headquarters at the Hotel Astor, in conjunction with the second National Exposition of Chemical Industries.

The Providence Society of Mechanical Engineers has been undergoing a reorganization and has now a membership of some 600. The quarters are in the building of the School of Design, in close proximity to Brown University. An interesting program is anticipated for the coming winter.

The American Society of Safety Engineers held its regular monthly meeting in the Engineering Societies Building, New York, on Sept. 27. D. C. Putney, director of safety for the Westinghouse Electric and Manufacturing Co., East Pittsburgh, addressed the meeting concerning safety as accomplished by the manufacturer.

MISCELLANEOUS NEWS

Explosion of the Boiler in E. H. Long's brick-manufacturing plant at Sturgis, Ky., damaged the plant and injured one man seriously.

The Scranton Electric Co., subsidiary of American Gas and Electric Co., according to the Philadelphia "News Bureau," has announced a new rate schedule effective Oct. 1, which will reduce the maximum rate for electric lighting from 10c. to 8c. per kw.-hr., with a minimum charge of 50c. instead of $1 a month. In all, the reduction in rates will average 20 per cent. The company has been making a large gain in business, and under the new rates it is expected that a much larger volume will be taken on.

Reduction in Power Companies' Assessments—The State Board of Equalization has made sweeping reductions in the assessments against power companies of Idaho, while in only two instances were increases made. The increases are 10 per cent. on the property of the Utah Light and Power Co. and 20 per cent. on the Thousand Springs Power Co. The reductions were: Washington Water Power Co., 20 per cent.; Lewiston-Clarkston Improvement Co., 10 per cent.; North Idaho and Montana Power Co., 10 per cent.; Northwestern Light and Power Co., 25 per cent.; the Canyon Creek Light and Power Co., 20 per cent.

Smoke-Abatement Ordinance—The City Commission of Lexington, Ky., has passed a smoke-abatement ordinance, to become effective on Jan. 1, 1917. Emission of smoke from stationary or permanent smoke-stacks in dense volume is prohibited, with these exceptions: For a period of 1 hr. per day while a new fire is actually being started under a cold boiler; two 20-min. periods daily during the fire-cleaning operations, at other times not to exceed 2 min. at a time or to aggregate more than 8 min. per hr. Penalties of $5 to $50 are provided, and the city building inspector is empowered to make inspection of smoke-stacks for violations.

Enormous Saving by Using Electric Power—It is reported that under its contract with the Montana Power Co., the Chicago, Milwaukee & St. Paul Railway Co. is paying at the rate of something like $500,000 a year for electric power to operate its 440 mi. of main line between Harlowtown, Mont., and Avery, Idaho. The same road paid for coal to operate its steam trains over the same line approximately $1,750,000. Another case of a large saving is that of the Butte, Anaconda & Pacific Ry., Anaconda, Mont., which is now paying less than $100,000 a year for its electric power, whereas formerly it cost nearly $275,000 for coal to operate its steam road, a saving of about $175,000 annually.

Large Electric Power Companies Merger—The long-expected merger of the big electric companies of Idaho has

transpired in the incorporation of the Idaho Power Co., with $17,000,000 capital. The Electric Investment Co., which was organized for the purpose of forming the giant merger, has been dissolved. While organized under the laws of Maine, the company is an Idaho corporation, 12 of its 16 directors being residents of the state. In the merger are the following companies: The Idaho-Oregon Light and Power Co., the Idaho Railway, Light and Power Co., the Great Shoshone & Twin Falls Water Power Co., the Idaho Power and Light Co., the Southern Idaho Water Power Co. and the Jerome Water-Works Co., together with a multitude of other properties controlled by these companies. The companies named control the entire territory of Idaho from Huntington, Ore., on the west to Blackfoot, Idaho, on the east.

Educational Exhibit—At the recent annual convention of the National Association of Stationary Engineers held at Minneapolis, the Newark, N. J., subordinate association had an exhibit of some of its educational methods for the purpose of not only stimulating greater interest in educational work, but attempting to interest the many associations in the standardization of association educational methods, of which there is a paucity. The exhibit as shown was unfortunately small on account of lack of room and because the threatened railway strike delayed shipment. It consisted of government literature, photographs of distinguished engineers in various fields of power engineering, studies in smoke production and abatement, central-station growth, specimens of sheets showing how the free public library coöperates with the association, curves, etc. The exhibit will be continued in the association rooms throughout the winter season.

BUSINESS ITEMS

The O. C. Keckley Co., of 608 South Dearborn St., Chicago, has been made western representative of the Homestead Valve Manufacturing Co., of Pittsburgh, Penn.

Sarco Company, Inc., in view of the increase of business, has opened a new office at 963 Drexel Building, Philadelphia, Penn., under the management of F. C. Perkins.

TRADE CATALOGS

Flexible Shaft. Stow Manufacturing Co., Binghamton, N. Y. Bulletin No. 102. Pp. 60, 6x9 in. Illustrated. A catalog of portable tools employing flexible shafting.

Portable Electric Tools. Stow Manufacturing Co., Binghamton, N. Y. Bulletin No. 101. Pp. 28, 6x9 in. Describes drills, grinders, screwdrivers and other portable electric tools.

Oil Reclaimer, Type B. De La Vergne Machine Co., Foot E. 138th St., New York. Bulletin No. 159. Pp. 8, 8½x11 in. Illustrated. Gives results of oil tests before and after reclamation and shows how the reclaimer is applied to a horizontal oil engine.

Ohio Brass Valves. The Ohio Brass Co., Mansfield, Ohio. Catalog No. 51. Pp. 144, 6x9 in. This describes and illustrates the different kinds of valves made by this company and contains data and charts on how to determine the proper size of regulating valve for a given service.

Fuel Testing Apparatus. Elmer and Amend, 205-211 Third Ave., New York. Bulletin No. 200. Pp. 32; 8x11 in. This describes the various types of calorimeters handled by this company, electric furnaces and the accessories, besides information on the sampling of coal and coal-testing methods.

A New Booklet giving many interesting details of "Permutit," the water-softening filter to zero hardness for industrial, textile and boiler plants, laundries, hotels and private residences, has been published by the Permutit Co., 30 East 42nd St., New York, and will be mailed to anyone interested on request.

Texaco Crater Compound, a lubricant for heavy work, is the subject of a 32-page pamphlet just issued by the Texas Co. It is elaborately illustrated with examples of the services to which the compound is adapted and will suggest means of meeting the difficulties of heavy gears and bearings in situations exposed to water and to excessive heat. Copies may be had free upon application to any of the company's offices.

Carrier Humidifying Apparatus. Carrier Engineering Corp., 39 Cortlandt St., New York. Bulletin No. 100. Pp. 46; 6x9 in. Briefly, this bulletin explains such details as air supply; fixing the amount of water vapor; heating; cooling; securing various humidities from one apparatus; air-distributing systems based upon ordinary galvanized-iron ducts; interior risers, hollow pilasters, central vertical flues; automatic dew-point control; proportioning fresh and return air.

Scientific Appraisals. The Manufacturers Appraisal Co., of Cleveland, Ohio, has issued a 32-page booklet setting forth the scope of its work in appraising properties of all kinds in determination and settlement of fire insurance, distribution of overhead charges in cost accounting, settlement of estates, adjustment of partnership interests and as a basis for mergers, sales, bond and security issues, etc. The booklet contains numerous "pointers" not likely to suggest themselves in the ordinary course of business.

Proposed Construction

Ark., Yellville—City purchased electric-light plant and plans to improve same.

B. C., Vancouver—Hotel Vancouver plans power plant.

Calif., Oroville—City Council plans lighting system.

Colo., Craig—Meeker Electric Co., Meeker, applied to Council for franchise to construct electric-light plant in Craig. W. Laidlaw, Meeker, Owner and Mgr.

Colo., Estes Park—City plans to purchase plant of Stanley Park Electric Light and Power Co. and to improve and extend system.

Ga., Damascus—City plans to install electric-light plant and water system.

Ga., Gainesville—Etowah Milling and Power Co., Atlanta, plans a power plant on Etowah River, Gainesville. J. P. Given, president.

Ga., Milledgeville—Georgia Prison Comn. plans to install electric-light plant at State Form, Milledgeville.

Ill., Burnside—City plans to install electric-light plant. J. Wright, interested.

Ind., Anderson—Remey Electric Co. plans 3-story addition to its plant.

Ind., Hartford City—Muncie Electric Light Co., Muncie, plans to improve system in Hartford City. The present plans call for an expenditure of about $10,000 on this improvement.

Ind., Laporte—Laporte County receiving bids Oct. 5 for electric-light and power plant. F. A. Hausheer, Laporte, county auditor.

Iowa, Littleport—Schmidt Bros. & Co., Elkader, applied for franchise to supply electricity to Littleport and transmission line from Littleport to Elkader.

Kan., Bridgeport—Gypsum Light and Power Co., Gypsum, plans to install electric-lighting system in Bridgeport.

Kan., Lenora—City election Oct. 26 to vote on bonds for electric-light plant.

Kan., McPherson—City plans to improve and extend electric-light plant and water system.

Kan., Moran—City voted $12,000 bonds for electric-light system. W. B. Rollins & Co., 439 Railway Exchange Bldg., Kansas City, Mo., engineer; W. F. Young, city clerk.

Kan., Wichita—Kansas Gas and Electric Co. plans additions and new equipment to plant. About $300,000. J. M. Strike, Wichita, engineer of power station.

Md., Baltimore—Bd. Education appointed committee to make investigations relative to installation of electric-light plant in Normal School.

Minn., Echo—City plans electric-light plant.

Mo., St. Louis—Knobnoster Electric Co., recently incorporated with $20,000 capital stock, will equip an electric-light and power plant. R. W. Morrison and W. S. McCall interested.

Neb., Beatrice—City votes Oct. 17 on $25,000 bonds for improving electric-light system. A. J. Pethoud, city engineer.

Neb., Beatrice—City votes Oct. 17 on $35,000 bonds for electric-light plant and system. H. M. Garrett, clerk.

Neb., Burchard—City sold $4,000 bonds for electric-light plant.

Neb., Helvey—City plans to install electric-lighting system.

Neb., Wolbach—Martz Engineering Co., Engr., Orpheum Bldg., Lincoln, making plans for power house and distribution station. About $10,600.

N. Y., Elmira—Elmira Water, Light and Railroad Co. granted franchise for electric-light plants and distributing systems in Montour, Catherine and Odesa. T. A. Brown, Engineer.

N. Y., Yonkers—A. Smith & Sons, Palisade Ave., plans 1-story boiler house.

Ohio, Circleville—Circleville Light and Power Co. plans to extend transmission lines to Williamsport and Clarksburg.

Ohio, Fremont—Herbrand Co. plans to spend about $200,000 for power house and plant for railway switch system.

Ohio, Middletown—Colin-Gardner Paper Co. plans to enlarge power plant.

Ohio, Newcomerstown—City plans electric-lighting system.

Okla., Alva—City plans to install electric-light plant. O. A. Hunt, Watonga, interested.

Okla., Olustee—City Council plans the construction of an electric-light plant.

Ont., Sudbury—British Canadian Nickel Co. plans power plant.

Ore., Bend—Pringle Falls Electric Co. plans power plant.

Penn., Erie—Erie Lighting Co. is making plans for a substation. Day & Zimmerman, Philadelphia, architect.

Penn., Erie—Hammermill Paper Co. making plans for 3-story, 88x116-ft. power plant. About $50,000. Osborn Engineering Co., 740 Engrs. Bldg., Cleveland, consulting engineer.

Tex., Kingsville—Texas Southern Electric Co. plans power station. H. A. Shaner, Victoria, engineer of power station.

Tex., Rowena—City plans to install electric-lighting system.

Tex., Sweet Water—West Texas Electric Co. plans enlarging electric-light and power plant. J. Hall, Sweet Water, manager.

Wash., Spokane—Spokane Heat, Light and Power Co. plans heating plant at Railroad Ave. and Post St. About $36,500.

Wash., Vancouver—North Coast Power Co. plans to spend about $60,000 for improving its system.